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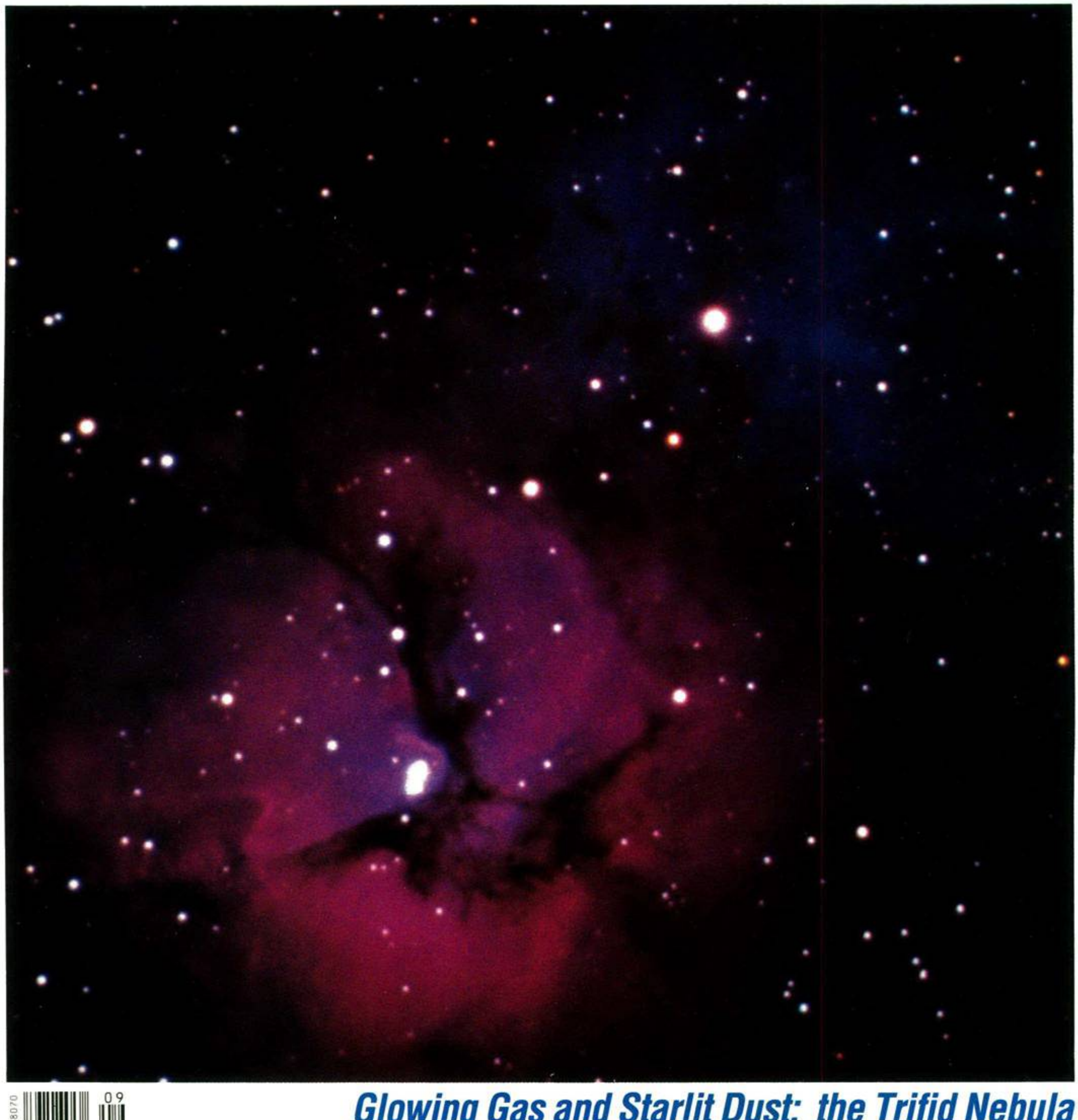

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Map Light	Yes	Yes
2X Corrections East-West	Yes	Yes
2X Corrections North-South	Yes	**No**[1]
Declination Motor	Yes	**No**[1]
RA Slewing	8X speed	**4X** speed
Declination Slewing	8X speed	**No**[1]
Continuously Variable Freq. Control	Yes	**No**
Illuminated Reticle Control	Yes	**No**
Optional Digital Readouts	Yes[2]	**No**
Encoder Outlet	Yes	**No**
AC and DC Adapters	Yes	**No**[3]
Ammeter	Yes	**No**
CAT™ Computer Outlet	Yes	**No**

[1] Optional Dec. motor priced at $170 additional. [2] Includes digital coordinate readouts; digital timer; RA freq. display with King rate; local time; sidereal time. [3] Optional adapters priced at $58 additional.

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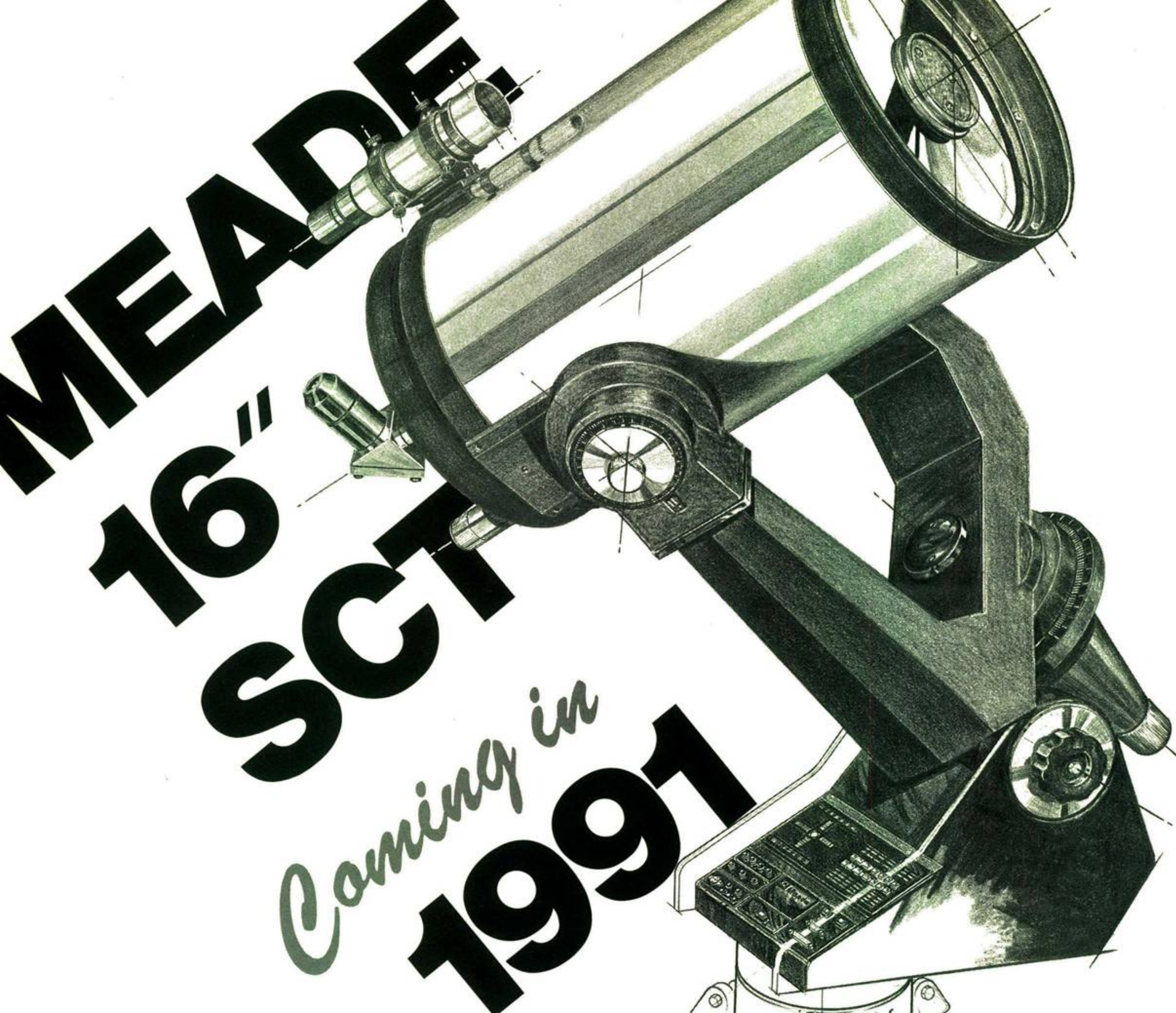

Eagerly anticipated throughout its 3-year development, this greatest of all Meade Schmidt-Cassegrains, the 16″ Model 2600, will be available for delivery in early-1991.

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Suggested List Price, Base Model: $12,500. (Orders placed before 11/1/90 qualify for the special introductory price of $9,950.)

For complete information on the 16″ Meade Model 2600, please write to Meade Instruments, requesting Technical Data Sheet #2600, available at no charge.

ON THE COVER: Magnificent reds and blues of the Trifid Nebula in Sagittarius show the promise of Fuji's new "super film," HG 400. (See page 62.) Photo by Tony Hallas and Daphne Mount.

COMET AUSTIN PASSES M31, the Andromeda Galaxy, in the early morning sky of April 19, 1990. For coverage of Austin's apparition, see pages 71 and 85. Photo by Ronald E. Royer.

ASTRONOMY®

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The Audit Bureau

Behind the Scenes

HUBBLE'S TROUBLES

Like a bomb bursting, the news that NASA's recently launched *Hubble Space Telescope* suffers from severe spherical aberration exploded in the astronomical world. Due to an error in fabrication, one of the two mirrors in the optical system does not have the correct curve.

The bombshell fell at press time for our September issue. Our feature story on *HST* was rendered instantly out of date, and there was too little time to rewrite it. As I write, it's still too early to assess the full impact of *Hubble's* problem.

Here's what we know: *HST* forms a star image with a tiny, sharp core 0.07 arcseconds across that contains roughly 15 percent of the image's light. The core is surrounded by a halo ten times larger, comparable in size to images formed by ground-based telescopes.

The error on the glass surface is only about 2 microns, but it produces an optical error of seven waves of light. For comparison, amateur telescope makers aim to make their optics better than 1/4-wave.

HST's imaging problem will be corrected three years from now, when astronauts place a new high-resolution camera with aberration-correcting optics in the telescope. By building an opposite but equal aberration into the camera optics, optical designers will cancel the error and *Hubble's* vision will be freed of spherical aberration.

Here at ASTRONOMY, we're looking hard at feature stories we had scheduled for the coming months. For three years, *Hubble* won't be doing much in the way of exploring the outer edges of the universe. Nor will *Hubble* be able to examine the environs of quasars or take pictures in search of planets orbiting nearby stars. Clearly, stories reporting discoveries in these areas will have to wait. So, too, will stories that display the latest and greatest high-resolution images.

Nevertheless, *Hubble's* scientific capabilities remain impressive. *Hubble* retains most of its planned capability to do ultraviolet spectroscopy and photometry, and astrometry will not be compromised at all. Imaging in ultraviolet light will not be severely impaired. Furthermore, through extensive image restoration, images of bright objects like the cores of galaxies may attain the full resolving power of the telescope.

At a time when it's easy to be cynical, I want to make plain that ASTRONOMY fully supports NASA and the *Hubble Space Telescope*. We are confident that in time *Hubble* will perform its job as intended.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

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Letters

Words into Black Holes

Please send me a box of "sentence endings." Then I can finish your articles, such as the one on "The Fiery Fate of the Solar System" (page 22, April 1990), "Pennsylvania Light Pollution Victory" (page 16, June 1990), and "How Faint Can Telescopes Go?" (page 17, June 1990). To leave a sentence unfinished is really — *H. A. Klug, Fresno, California*

—Sorry about that. We didn't intend to leave you or any other reader hanging! The missing words are, April, page 22, "greenhouse," June, page 16, "if we can repeat our success," and June, page 17, "recent return."

What happened in those issues was that in the transfer of the stories from our electronic page-layout system to the one that prepares the magazine for the printer, a few words here and there-disappeared at the ends of

Double Sky Vision

A quick glance at the Sky Almanac map in the May issue showed a funny-looking sky. After taking a careful look I saw a pattern emerging: Alpha and Beta Leonis were side by side, and so were Betelgeuse and Procyon. Then I matched the map with the one in the April issue and saw that your printer delivered a map showing the sky in double vision. Your maps are usually the finest available, and I hope that in the future you'll keep up the standard of excellence. Be assured that your readers think the sky as it really is is quite exciting enough. — *Mick Deckman, Parker City, Indiana*

—We're really sorry about doubling the sky in our May star map. The printer made an error that repeated the star pattern, and it slipped by us in our checking proofs for the issue. We're now watching for this and it shouldn't happen again. Still, for that month, we gave you twice the stars for your money.

Gaps in Name Only

I very much enjoyed Karen Hartley's fascinating article on chaos in the solar system (May 1990). However, I would like to clarify the impression readers got of the Kirkwood gaps. They are not, as one might surmise, actual gaps in the asteroid belt where no asteroids can be found. Rather, they are gaps in a graph plotting numbers of asteroids versus the orbit sizes (the major axes of the orbital ellipses). Because the orbits are ellipses rather than circles, an asteroid's dis-

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There's no question large aperture reflectors like John Vogt's excellent 30" f/3.8 produce deep sky views rivaling those I've seen in major observatories. But his scope, like yours, is limited in field sharpness. The main offender is coma, an aberration which makes stars look like blurry comets. Visually and photographically, the faster the scope the worse the effect.

If we compensate for coma before starlight reaches the eyepiece, then the best eyepieces will be used to fullest advantage, and a sharp full frame 35mm photograph is possible. In sum, my design goals were:

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I hope you agree that Paracorr, the coma eater, is the missing link necessary to fully enjoy your "DobNewt."

—Al Nagler

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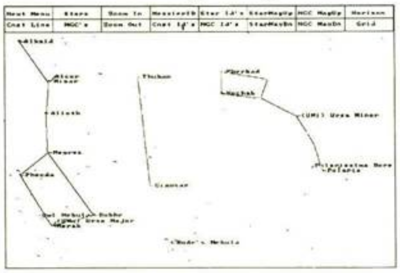

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tance from the Sun varies considerably during its orbit. Consequently, asteroids whose major axes are slightly greater than or less than the gap value wander across the "gap." If you could see the asteroids from a distance, you would not see any gaps in their distribution in space. — *Stephen Lloyd, City College of San Francisco, San Francisco, California*

Is Amateur Astronomy Declining?

Many amateur astronomers these days seem to be discouraged. It seems that astronomy clubs in some areas of the country are experiencing declining membership rolls. Part of the problem may be that young people are not inspired to look at the sky like they once were. Twenty years ago the Apollo program whet the appetites of many young people who became amateur astronomers. Nearly every school in the country taught something about space exploration as part of its regular curriculum. Many of the kids who grew up in the 1960s went on to become active members of astronomical societies in the 1970s and 1980s.

Amateur astronomy needs something to motivate young people to take an active role. The problem is that in our computer and whizz-bang television era, the basically static Moon and planets do little to excite young minds. After talking about astronomy with numerous youngsters, I've found that one thing stands far ahead of any other in terms of excitement — meteors. I suggest that to increase interest in amateur astronomy, bolster the ranks of astronomical societies, and ensure the future good of astronomical activities, clubs publicize and hold observing sessions for meteor showers. Perhaps our new slogan ought to be "Show a Kid a Perseid!" — *Clive A. Cadle, Bethany, Oklahoma*

Rename the Dumbbell?

On the cover of your May issue you ran a photo of M27, the Dumbbell Nebula in Vulpecula. The image was beautiful and showed that object better than any I remember seeing. However, it's a shame to call such a pretty object a name that sounds so desultory. I suggest that M27 be renamed the Apple Core Nebula. Any takers? — *Dave Grove, Wapato, Washington*

—The Dumbbell Nebula is named after its resemblance to the shape of a weight used for lifting. We value your suggestion but feel that, for better or worse, we'll continue to call M27 "The Dumbbell."

Observing the Horsehead Nebula

I found "The Lure of the Horsehead Nebula" (Reader Reports, June 1990) very interesting because of my own efforts to see the Horsehead over a period of several years. One of the great mysteries about the Horsehead is that it is visible to some observers equipped with relatively small telescopes and invisible to other observers with large telescopes. I know that some observers have glimpsed the Horsehead in 5-inch telescopes while others have missed it using 30-inch or 40-inch instruments.

I suspect that two factors are more important than aperture for seeing the Horsehead. Sensitivity to red light is of tremendous importance because IC 434, the dim strip of emission nebulosity behind the Horsehead, is strongly red in color. Red sensitivity varies considerably from observer to observer, which helps explain some differences in spotting the Horsehead in different aperture scopes. Contrast is also a tremendously important factor. You must observe from a dark-sky site. If you don't use a system that delivers high-contrast images, you can forget about seeing the Horsehead.

I use an 8-inch f/10 SCT and a 16.3mm Galoc eyepiece that yields a magnification of 125x, which provides high-contrast images. I have seen the Horsehead several times with this setup from my back yard, but I must be very careful to look in exactly the correct place. The key to seeing the nebula is to make a careful diagram of the field stars that surround the small Horsehead. On nights that are very dark and dry I can see the object with direct vision, but it is not shaped like a horse's head. Instead, it is a small, dark notch in the nebula IC 434. — *John J. Brooks, Santa Ynez, California*

Congratulations to David Higgins for his excellent article on the Horsehead Nebula ("Stalking the Elusive Horsehead," January 1990). Higgins reminded me that achieving a seemingly overwhelming goal in observing has as much to do with observing skills as it does with equipment.

My last try at finding the Horsehead Nebula was a long and exasperating ordeal. After searching for a considerable amount of time, I felt that I *might* be seeing IC 434, but not that spooky, dark chess piece. I've talked to other observers who also thought they had seen the nebula, but not one of them was sure.

Next autumn I'll be outside trying again, caught by the challenge of flirt-

DEAR MR. NAGLER,

Several years ago, I purchased a 10" Schmidt-Cassegrain telescope. On this new instrument, I carefully compared the performance of the most respected brands of eyepieces before concluding that the **Tele Vue** Plössls were giving me the best views. Along with 4 of your Plössls (55, 26, 17 and 13mm) and your 2.5x Barlow, I bought a Giant Off-Axis Guider, which I frequently use as a telecompressor. Although I have always been pleased with your eyepieces, there are limits to just how much a long-focal-length telescope can be telecompressed! ■

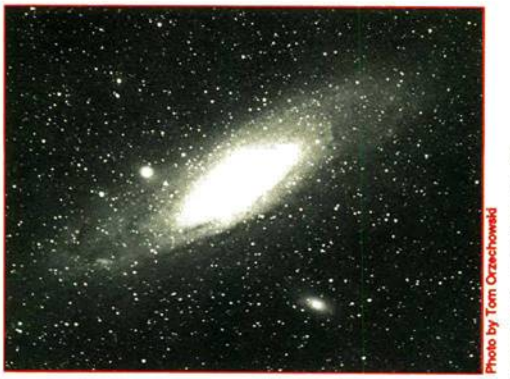
Photo by Tom Orzechowski

AN OWNER'S VIEW:

Genesis™

For over three years, I have wanted a second instrument for rich-field observing and photographing. Although your **Renaissance** is most impressive, it just wasn't quite the instrument I wanted and the **Oracle** was a bit too small. Then came **Genesis.** Knowing what a stickler you are for details in both design and production, plus my total satisfaction with your eyepieces; sight unseen, I bought a **Genesis** based solely on those facts and your ads in the magazines. ■

I took delivery of my **Genesis** at the Texas Astronomical Society's meeting on 7/22/88. Even with all the light pollution in that North Dallas parking lot, my new **Tele Vue** 32mm Wide Field eyepiece, at less than 16x, clearly resolved Saturn's rings as separate from the disc. When a friend asked to try his 12 mm Nagler-II with his 3x Barlow, I knew I had bought a "winner." The Cassini Division was as sharply defined as I have ever seen it plus the surface and ring detail was second only to a view I once saw under a Texas Star Party's dark skies through a nearly $20,000, 10.7" f/15 Maksutov! ■

The reason for this letter is simple. I have now had my first opportunity to take my new **Genesis** out to the T.A.S.'s dark-sky observing site (100 miles north of Dallas). In short order, the **Genesis** had attracted a group of experienced observers (most holding full Messier Certificates) away from their larger telescopes. Simply, **Genesis** stole the show! Except for an occasional comparison view, my 10" Schmidt-Cassegrain sat idle because I was seeing far greater clarity and detail with my new **Genesis.** Although I had with me a full set of filters (Deep Sky, U.H.C., O-III and H-β), none were ever used. ■

While I had anticipated a gorgeously resplendent Double Cluster, it was truly more dazzling than I expected. But, some real surprises lay ahead. Take M-33 in Triangulum: 4" just isn't enough aperture for such a diffuse spiral, right? WRONG! With the 32mm Wide Field, I was seeing tremendous detail in a galaxy over 1/3 the width of the field. I could write paragraphs describing a California Nebula covering half the field plus all the glorious sights through Sagittarius and Scorpius like the Lagoon, Trifid and M-21 all in the same field; or, four gleaming globulars, M-22 & 28 with NGC-6638 & 6642. ■

While the Great Andromeda Galaxy (M-31) spread across more than 2/3 of the field, we were all alternating time at the eyepiece, trying to see who could count the most dust lanes. It was more beautiful than even the photographs from the leading observatories. I have never seen M-110 appear as large relative to M-31. One observer even held his hand in front of the eyepiece and suggested that we try observing a projected image! While that may have been beyond even **Genesis'** capability, it does prove we were looking at no dim M-31. There was a debate over which eyepiece provided the better view: the 13mm Nagler's greater contrast and detail or the 32mm Wide Field's greater coverage. Each outperformed the other in its own way and both provided splendid views. ■

All night, comments from seasoned observers included a thesaurus-full of one word expletives of praise, wonder and astonishment. While glued to the eyepiece, other comments included: "... but this is ONLY a 4-inch" to "Boy! You sure made no mistake in buying this one" and "Oh, No!... How am I ever going to make my wife see the need?". One observer even yelled to a friend acoss the field, "Get over here if you want to see what Rich Field is SUPPOSED to look like." Personally, I can hardly wait to start taking astrophotos with it. ■

In case you could have possibly missed

I am totally enthralled

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the fluorite element as a totally internal component, inaccessible to dew, condensation or scratches. ■

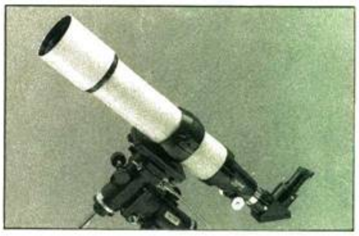
DEAR MR. LEDLOW:

(From one owner to another, we present two unsolicited letters about Genesis)

Having purchased a Genesis and barely given it a trial, I can believe that your "Dear Mr. Nagler" letter is genuine: not ad agency copy. Also using the Nagler 7mm eyepiece, I am hooked. Champagne tastes suddenly acquired on a beer budget! Hope my 8" SCT doesn't sulk!

-Roy Woodland, ONT.

P.S. But Mr N. in a word WOW!!



It would have been impolite of me not to write and tell you just how much of a Big Bang your **Genesis** telescope has already created in my deep sky observing. ■

Appreciatively yours,

Kent G. Ledlow

Kent E. Ledlow

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ing with a nearly unattainable goal. — *Robert E. Bjornstedt, Lebanon, Oregon*

Who Saw the Echo First?

I noted with interest the photographs by Steve Quirk showing the light echo from Supernova 1987A you published in Reader Reports (February 1990). Equally interesting was the claim that he was the first amateur astronomer to photograph the light echo.

I successfully photographed this phenomenon on June 20, 1988, fourteen months before Quirk's photos were made. The presence of the light echo on my photos was confirmed by variable star expert Frank Bateson. — *Larry Purcell, Bangor, New South Wales, Australia*

No Red Star Charts, Please

One of the first things I learned in U.S. Navy Quartermaster's School was never to write any information on a chart in red ink. You've done just that with your Pluto finder chart ("Hunting the Last Planet," April 1990). Most observers know what happens in the dark when you shine red light on red lines and dots. Please don't do it again! — *John D. Phelps, Orland Park, Illinois*

If Venus Had a Moon. . .

Stephen Saunders' article on Venus (March 1990) gives the impression that Venus had an evolutionary path identical to Earth's and that we may be able to predict the fate of Earth by carefully studying Venus. Unfortunately, the article fails to consider the possible role the Moon played in Earth's history. Was the hypothetical collision of the proto-Moon with Earth responsible for the higher mass density and the continued differentiation process on Earth? Did regular lunar tides assist the formation of the oceanic microorganisms that were responsible for starting the carbon cycle, which checks carbon dioxide in Earth's atmosphere? Did the other terrestrial planets miss out on starting life because they lacked a massive satellite?

Whatever role it played, certainly Earth's hefty Moon should be considered in any such analyses. — *G. H. Azarbayejani, Union Lake, Michigan*

The Salvation of Albion

After nearly twenty years of sporadic use, the 8-inch Alvan Clark telescope at Albion College in Albion, Michigan, is being fully restored. James Ehlers, an amateur astronomer and freshman at the college, is spearheading the project of refurbishing the telescope and the dome's interior. The telescope will be restored by the Dobbins Instrument Company of Cleveland, Ohio.

The Albion instrument was reportedly made by Alvan Clark himself and was supposedly the last instrument made before his death in 1887. *Scientific American* stated that Clark stopped building telescopes about four years before he died, and this telescope was built in 1883.

Eighty years later Harlow Shapley examined the Albion telescope and told college officials they owned a "Rembrandt." The college owes a great deal to the infectious enthusiasm of James Ehlers, which will save the telescope from apathy and oblivion. — *R. Stephen Franks, Detroit, Michigan*

Astronomers Just Wanna Have Fun

I enjoyed Stephen Edberg's article "Astronomy is Fun!" (Viewpoint, March 1990). My days as an amateur astronomer have spanned 15 years and I am still interested in the hobby because it has never ceased to be great fun. To quote Edberg, "Fun in astronomy is where you find it." For me it has occurred on a trip to the Mississippi Gulf Coast to view Halley's Comet, taking my two daughters to a dark sky site outside of New Orleans to view deep-sky objects, staring at an ultra-rare southern aurora, viewing transits of Mercury, and finding every planet except Pluto. (I'm saving some of the fun for later.)

By sharing my experiences in amateur astronomy with my family and friends, I've found it to be a particularly enriching hobby. — *Kerry M. Finney, New Orleans, Louisiana*

How to Flop the Moon

I read with interest Brian Zemach's letter about the difficulty of obtaining a reversed map of the Moon for observing with a reflector (Letters, April 1990). I suggest he find a commercial photocopier who can copy maps onto acetate sheets. Once this is done, simply flop the acetate sheet backwards and photocopy it onto normal paper. This yields a perfectly reversed image of the Moon useful for observing. — *Lyndall Barbour, Salisbury, Wiltshire, England* ☐

ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

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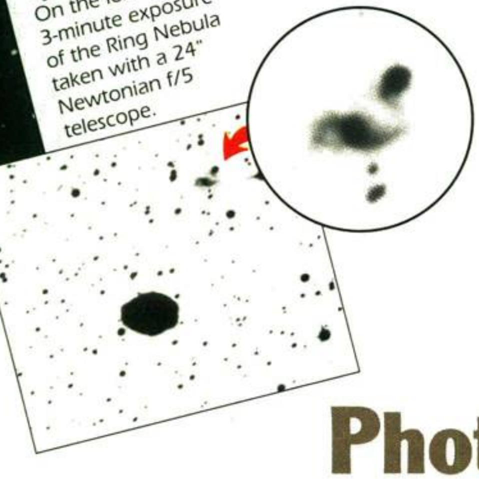

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CALEDONIAN GRAPHICS

WHERE IS AMATEUR ASTRONOMY GOING?

After ASTRONOMY's editors returned from this year's Texas Star Party and Riverside Telescope Makers Conference, we asked them to talk about the trends in amateur astronomy. David Eicher, Richard Berry, and Alan Dyer, from ASTRONOMY's editorial department, and Greg Swan from ASTRONOMY's advertising department, are the participants. Robert Burnham of ASTRONOMY's editorial department moderates the discussion.

Robert: Well, you've been to the 1990 Riverside and TSP. What did you see there?

Richard: Riverside was more commercialized than ever before. I don't want to label that as a bad trend, because it means there are more goodies for both beginners and serious amateurs than ever. I'm concerned, however, that so much commercial activity can make amateurs feel strangers to their own hobby.

Alan: Yeah, I agree. Increasing commercialization is nice in that it brings a lot of interesting products to the market. These can help beginners. They can also add enjoyment for the people who are already well entrenched in the hobby. But the profusion of products makes it difficult for the beginner to get oriented, and also makes amateur astronomy seem intimidating and expensive. Many beginners think they've got to spend a lot of money just to get started.

Richard: Especially because you can get started in astronomy with nothing but your own two eyes.

Dave: When stuff gets popular everyone has to buy it, and that's off-putting for beginners. I fear that new accessories encourage competition and discourage newcomers to astronomy. That's not what amateur astronomy is or should be about.

Alan: Yeah, owning a lot of stuff, even as useful as a lot of that stuff is, has become almost a status thing. Lots of people seem to think you have to have all the latest gadgets or the latest generation of telescopes.

Richard: Let me toss out another point. At Riverside this year, I saw very few teenagers or people in their twenties. But there were a lot of people in their forties and fifties. Where are the young people? It's important for the hobby that young people discover astronomy and get involved in it.

Dave: Young people live in a television-oriented "now" society in which bright, whizz-bang, fast-moving, attention-grabbing graphics are the standard. I'm concerned that images of galaxies and even of the Moon and planets in a telescope are simply not exciting enough to attract kids.

Robert: Are those kids going somewhere beside Riverside or TSP, or are they really not getting into the hobby of astronomy at all?

Alan: I know that kids are still interested in astronomy because I've conducted a lot of public observing sessions. I find that views of things through telescopes still excite people, especially young people, as much as they've ever done. Certainly there is as much interest now as there ever was, if not more, because the educational level of the public is much higher. People know a lot more about space and astronomy than they ever did.

Dave: In the sixties, kids were taught about lunar science, about the basics to go along with *Apollo,* all coming out of *Sputnik,* of course. Do you think that's still as present in primary and secondary education as it used to be?

Alan: It's not gotten any worse or any better. To a large extent it still depends very much on the teachers. If it's gotten any better or worse, it's because the teachers are more or less interested in astronomy than they used to be. The kids are as interested as ever.

Richard: It strikes me as paradoxical that while we're saying we don't see many young people, we *are* seeing more and more local and regional meetings and all-weekend star parties.

Dave: And those meetings attract hundreds of people. It used to be that only two or three major conventions did that. Now there's a dozen or more regional meetings that are attracting notice.

Alan: The regional star parties are becoming the way a lot people enjoy astronomy. It's almost as if the annual star party in their region is the only opportunity people have to do dark-sky observing.

Dave: It's safe to say that they'll only become more important as time goes on.

Robert: We've been talking about meetings here. To what extent do these meetings reflect the hobby as a whole?

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Greg: Pretty well. ASTRONOMY's surveys show that the average age of our readers is 41.8 years. Just five years ago, it was 36.3, so it's gone up 5.5 years in the last 5 years.

Alan: It's the same group?

Greg: Possibly. But we know that the Riverside people are not representative of the ASTRONOMY reader. Riverside doesn't attract typical astronomy hobbyists — it attracts the die-hards who are really into it.

Dave: Maybe there weren't young people, but there were a larger number of women at Texas this year — and they were not all spouses. They were actively involved women who brought their own telescopes to the meeting, and they were talking astronomy.

Greg: According to the latest survey, there are 3,200 more women active in amateur astronomy today than there were five years ago.

Robert: From what Greg is saying, it sounds like the people in the hobby have much the same characteristics as they have always had. But now I'm wondering: are there new technological developments which, if you project them into the future, will change the hobby?

Richard: Certainly the hottest thing in the equipment area now is the emergence of low-cost and very capable CCD cameras. Probably at this point only a few hundred units have been sold, but I'd predict that those sales are going to grow almost exponentially.

Alan: They're going to become a lot more popular, but I think they'll gain the most popularity among a select subset group of the hobby, much as astrophotography has.

Richard: I agree. Using a CCD camera is probably tougher, on the whole, than astrophotography is. But CCD cameras provide instant and intense satisfaction.

Alan: For the beginner just getting into astronomy, CCDs have got to be intimidating. They increase the ceiling of what you can spend in the hobby.

Richard: They aren't for the novice.

Dave: I don't see CCDs, frankly, as affecting other areas of astronomy greatly. Meanwhile, they'll provide a great deal of fun and enjoyment for a lot of people. But there's a limit to what you can do with a CCD.

Greg: You need a computer to use a CCD camera, right?

Alan and Dave: That's right.

Greg: Many of our readers have computers. In the last five years we've added 9,600 computer users to our

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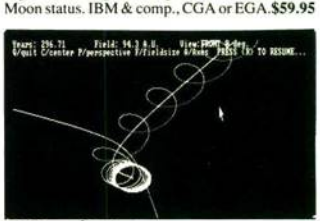

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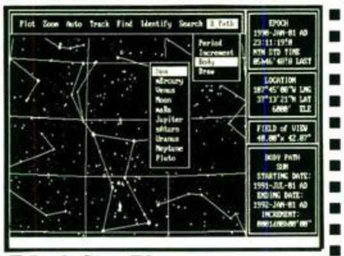

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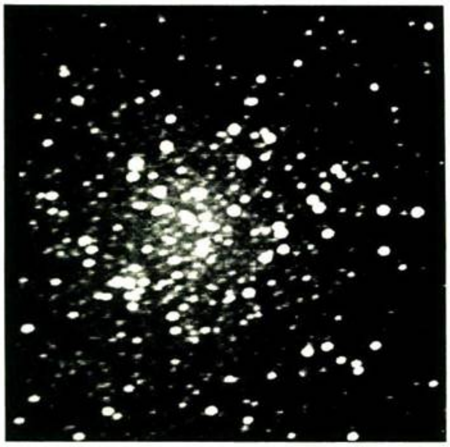

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Alan: And CCDs are something you can do with your computer.

Richard: I think the driving factor with CCDs is the instant satisfaction they provide. As soon as the exposure is over, a picture comes up on the screen. Bingo! The other thing is that you can store the image in the computer and call it up and show your friends the next day.

Alan: They're also possibly the ultimate deep-sky observing tool. With a small aperture telescope, you can now reach 14th-magnitude galaxies that you...

Dave: Oh, yeah? Well, I would argue that looking at a TV screen is not observing.

Richard: Not at all! With a CCD you can pull out objects that are much closer to the level of sky background than you can by eye, or with conventional astrophotography. Why is that not observing?

Dave: It's not an equivalent satisfaction from the observer's point of view. It's a completely different thing from visual observing.

Alan: CCD imaging, because it's real time, is a lot closer to real observing than photography. That's Richard's point. The distinction between taking live CCD images and looking through an eyepiece is going to be blurred. It will be observing, whether it's through an eyepiece or...

Dave: Not for deep-sky observers. I know that because I've asked them specifically about it.

Alan: For the real hard-core observers today I agree, but the next generation of people who are coming into the hobby could see it differently.

Dave: This is what was said about and is exactly analogous to what happened with astrophotography circa 1870. Isaac Roberts started taking photographs and telling everyone how photography was going to supplant the eye...

Richard: And professional astronomers really did stop looking through telescopes.

Robert: I think there are many different satisfactions to be found in amateur astronomy. What concerns me is that it's very easy for beginners to think that one highly visible aspect of astronomy is all there is. That could drive some people away.

Dave: Again, you have to look at what you're ultimately getting out of it. If you try to convince me that it's going to be any more fun...

Robert: People can have fun in many

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different ways and don't necessarily do one thing all their lives if they're in the hobby. For a while they may go into astrophotography and pursue it rigorously, and after 6 months or 10 years, the itch is scratched and they move on to something else.

Alan: It's my impression that astrophotography has declined somewhat in popularity. A few years ago astrophotography was a must-do thing if you were into astronomy.

Dave: That was in the 70s. I think it's picked up again in the last three years. Also, now we've got much faster films and better films, and autoguiders that make it much easier to make long-exposure guided photos.

Alan: The standards for deep-sky astrophotography have become so high that they discourage people from getting into it. Yet that isn't necessarily what people have to do for astrophotography. With a simple camera-on-tripod technique you get some marvelous results — very beautiful images, compositions. But they're not hour-long deep-sky exposures. That isn't necessarily what astrophotography has to be.

Robert: I sense behind this discussion some confusion between tangible results and the process whereby you achieve them. If you view amateur astronomy as process, then people who buy a push-button telescope to capture images on a computer and claim, "Yes, I've done it," in a very real sense haven't done it at all. All they've done is pay for it.

If, on the other hand, you laboriously star-hop your way to some deep-sky object that's right at the edge of visibility, you then come away from that with a real sense of achievement. The observational craftsmanship, then, is the real achievement, at least for me.

There are people who, quite frankly, go into the hobby to make images of celestial objects — as many as they can, as beautiful as they can, as fast as they can — and that's fine. For myself, I'm happy out in my yard putzing around with my 6-inch f/8 Newtonian, just looking at things and finding my way to something that I've not seen before.

Alan: You're a throwback!

Robert: Yes, I know I am.

Richard: But CCD imaging is not that simple. It's harder than astrophotography. It takes skill and craftsmanship to coax fine results from any device.

Dave: Can we agree that there's a place for both? After all, there's only so much time in this life for doing things of this sort. Clearly, whether or not they're exactly the same thing, they're going to compete with each other for time and participants.

Robert: If CCD images are so great, why not send out one poor Joe to shoot all the pictures? Then everyone could see them the next day. Clearly the act of participation is important.

Richard: The fun comes from doing things, from participating. Watching someone else do something is hardly ever as much fun.

Dave: It's like telling somebody who enjoys bowling that just because Whatshisname bowls a 300 on the PBA tour when it's televised on ABC, you should never go bowling again. The guy does it because he enjoys bowling for itself and not because he wants to compete with professional bowlers.

Richard: And the high-tech folks are happy enough to go off and do their own thing with fancy electronics, while another type of person has gotten fascinated with heavy-duty deep-sky observing. They don't insist that everyone else be just like them.

Dave: I think the future will bring greater specialization. This is happening in other hobbies as well. In the last five years we've had an explosion of deep-sky information. Not only are we witnessing the development of much better equipment and hardware, but the information available is much better than it ever has been before.

Richard: There's room in this hobby for virtually every type and depth of interest. There's no need for anyone to feel left out.

Alan: The range of things you can do in the hobby is now much, much greater than it ever was before. But that very richness makes astronomy confusing and complicated for someone who is just starting out. They go to a star party and see all of this going on — bizarre, wonderful things — and they want this and they want that.

Robert: Those things turn off people who are low-tech or anti-tech or just nature-lovers who enjoy the night sky.

Alan: And so they reject getting a lowly portable telescope that could give them years of enjoyment because it just doesn't seem impressive compared to the 24-incher over there and the CCD system over here. That's where it stands right now. It's unfortunate, but we really have to get back to those roots. We shouldn't forget that exploring the sky for the first time through binoculars or a 4-inch telescope can be the most enjoyable experience you'll ever have, no matter where you go in the hobby. ☐

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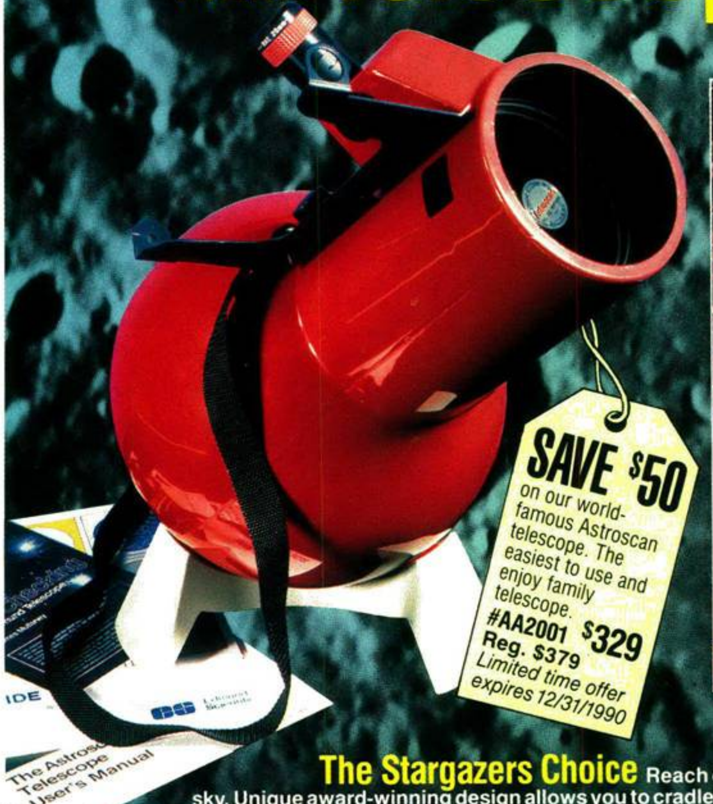

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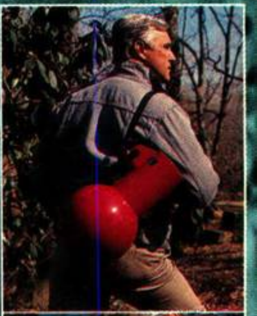

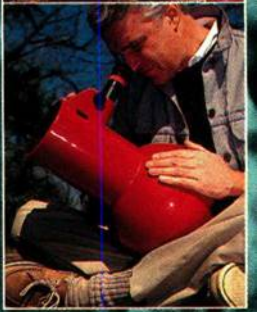

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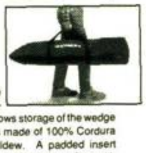

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Our best barlow offers significant improvement over other models we've seen. The magnification is adjusted by sliding the internal lens cell along a calibrated scale (you don't have to poke a finger or pencil inside to do this). Fully Multi-Coated optics provide excellent sharpness, contrast and brightness. 1.25" diameter.

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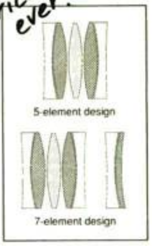

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12mm Kellner eyepiece with cable plugs into LX/3, LX/5 and Premier drive bases, and most drive correctors with illuminated reticle output for polar alignment and guiding.
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On Sale

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SkyGlow Broadband Filters-
For use in slight to moderately light polluted areas.

1.25" Broadband Filter- fits 1.25" eyepieces. #5660 Reg. $66.50 **$49** (2.19)

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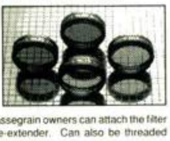

Solar system observations are dramatically improved by Orion colored filters. For visual use, thread one into the barrel of any standard eyepiece. For planetary and lunar photography, Schmidt-Cassegrain owners can attach the filter to the eyepiece inside the tele-extender. Can also be threaded directly into a universal camera adapter.

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Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.
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Adjustably reduces the light transmission of visual images, so you can see more detail. Also ideal for cutting glare from water, window glass during terrestrial observation.
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Standard Model-
Has adjustable-height center column and padded vinyl seat. Folds for easy storage.
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Is much heavier-duty, built for professional musicians. Extra thick padding, wide footprint. Adjustable, disassembles for storage. #5934 **$89.95** (5.65)

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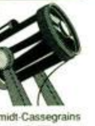
Allows eyes to adjust to night-vision in the comfort of your home. #5942 **$19.95** (1.89)

Orion® Dew Zapper



Orion's Dew Zapper is a sure-fire cure for dew problems on your 8" or 10" Celestron or Meade Schmidt-Cassegrain telescope. Dew Zapper gently replaces lost heat, bringing the corrector plate temperature slightly above air temperature.

8" Dew Zappers- fit all Meade & Celestron 8" Schmidt-Cassegrains
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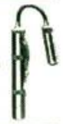

Features adjustable beam (narrow or broad). Fastens to shirt or pants pocket with unique clip. Red lens protects night vision. Gold anodized aircraft aluminum construction lasts a lifetime.
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Starlite Red LED Flashlight

The Starlite is the only adjustable-brightness night-vision red flashlight. Lifetime solid-state LED can't burn out. Extra efficient electronic circuit for long battery life. Uses one 9-volt battery (not included).
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5.0 Amp Hour Porta Pac
Perfect for Meade LX6, LX5, and LX3; and Celestron Powerstar 8, and SPC-8 (with adapter). Also suitable for all drive correctors and motor drives. Battery is encased in high-impact polystyrene. Built-in handle. Wt. 5 lbs.
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Unlike ordinary counter-weights, our system allows instant adjustment in both directions. Easily balances your scope to offset both piggyback loads or rear-cell cameras, 2" diagonals, and other accessories. Rigid, precision machined dovetail bar mounts to telescope in existing accessory holes.

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For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 8", 10" SC.
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Get four times brighter images and twice the field of view. For Meade, Celestron 8", 10" Schmidt-Cassegrains.
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1.25" Star Diagonal
Primarily for astronomical use, lets you view at a right angle. Multi-coated, for 1.25" eyepieces.
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Same as 1.25" Star Diagonal, but with standard coated optics. Works with .965" eyepieces and eyepiece holders.
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Adapts 1.25" eyepieces to .965" eyepiece holders of refractors and most compound reflectors.
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Get the widest possible field of view from your Schmidt-Cassegrain Telescope. This star diagonal features a special aluminized and overcoated precision first-surface flat mirror.
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Orion® Tele-Extenders

For high powered photography with your Meade, Celestron 8", 10" Schmidt-Cassegrain

Standard Tele-Extender
Use this Tele-Extender in conjunction with an eyepiece. Attaches to visual back of Meade or Celestron Schmidt-Cassegrain telescopes, and to 35mm camera with T-ring, sold separately.
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Uses an adjustable extension tube, allowing magnification to be changed without switching eyepieces. Thumbscrews lock extension tube securely in place. Attaches to 35mm camera with T-ring, sold separately.
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Orion® Tele Compressor

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Extension Tube #5123 **$19.95** (1.89)

Orion® Premium Off-Axis Guider

Use with any 1.25" Illuminated Reticle Eyepiece. For Meade and Celestron Schmidt-Cassegrains.
#5144 **$59.95** (1.89)

Universal Camera Adapters

Standard Universal Camera Adapters
Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors with 1.25" eyepiece holders. Use with T-Ring (sold separately) to match your 35mm camera.

.965" #5268 **$29.95** (1.89)
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Variable Power Camera Adapter
Unique sliding barrel design allows variable projection distances during eyepiece projection photography, eliminating the need to change eyepieces when magnification changes are required.
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BEST EVIDENCE FOR THE GREAT ATTRACTOR

New observational evidence bolsters the existence of the so-called "Great Attractor," a theorized realm of over-dense matter gravitationally pulling on galaxies in the local universe. In a paper published in the May 1, 1990, *Astrophysical Journal*, astronomers Alan Dressler of the Observatories of the Carnegie Institution of Washington and Sandra Faber of Lick Observatory report that 136 galaxies in and around the Local Group, which includes the Milky Way, are streaming toward this region of the universe.

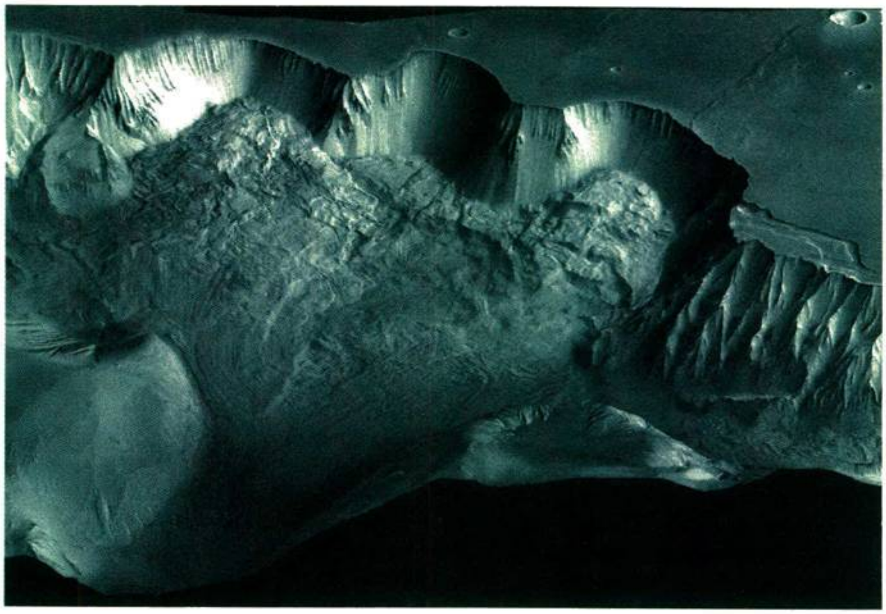
Dressler nicknamed the massive region the Great Attractor in 1987. Measurements of the motions of nearby elliptical galaxies by Dressler and five colleagues revealed a peculiar drift superimposed on the overall smooth flow of the expansion of the universe. The drift, which trends toward the Hydra-Centaurus supercluster in the southern sky, has a velocity of about 600 kilometers per second with respect to the cosmic background radiation. (Astronomers use the cosmic background glow as a fixed frame of reference to determine the proper motions of galaxies.)

The astronomers find that galaxies within 130 million light-years of Earth appear to be "falling" in toward the Attractor. Moreover, the velocities of galaxies beyond that distance appear to be smaller and decline to near zero at the distance predicted to be the center of the mass concentration, which lies about 147 million light-years away.

Marginal evidence also seems to indicate that some of the galaxies on the far side of the Great Attractor are falling in toward the Attractor's core. This evidence is inconclusive, the astronomers warn, because of the small number of galaxies measured as well as the uncertainties involved in calibrating the distances of these galaxies.

Astronomers estimate the Great Attractor spans over 60° in apparent angular size on the sky, from the Hydra and Centaurus superclusters through the plane of the Milky Way to the Pavo and Indus superclusters. This translates into an actual diameter of about 300 million light-years at a distance of 147 million light-years. The Attractor's mass is thought to consist of tens of thousands of luminous galaxies but is dominated by even larger amounts of dark matter. The Attractor's greater-than-average mass density results in a slower expansion rate in its vicinity relative to the universe as a whole.

Although the volume of the Great Attractor is vast by terrestrial scales, occupying perhaps 1 million cubic megaparsecs, it is a small part of the observable universe — less than one-tenth of one percent. Astronomers think that the Attractor probably is not a unique structure. In fact, such great organizations may be quite common in the universe. Confirming the existence of the Attractor is important not only for comprehending the structure and dynamics of our local region, but also for understanding the nature and formation of large-scale structures in the universe.



LANDSLIDES AND DEBRIS FLOWS scar the walls and floor of Ophir Chasma, a large "bay" in the northern edge of Valles Marineris on Mars. This recently processed view looking north spans an east/west distance of about 80 miles and has a 2x vertical exaggeration. Processing was done by Alfred McEwen of the U.S. Geological Survey in Flagstaff, Arizona.

LAKES MAYBE, BUT NO DEEP ETHANE OCEAN ON TITAN

A group of radar astronomers led by Dewey Muhleman of Caltech has paired NASA's Goldstone antenna with the Very Large Array radio telescope to probe the surface of Titan, Saturn's largest moon, using a 360,000-watt radar signal. Reporting in the May 25, 1990, issue of *Nature*, the team found that Titan's surface, hidden from view by an opaque orange smog, reflects radar signals in a way very similar to the Galilean moons of Jupiter, all of which have bare surfaces of ice, rock, or a mixture of the two.

These results rule out the deep ocean of ethane that has been proposed in the past by planetary scientists, who based their hypothesis on the physical conditions at Titan as profiled by *Voyager*. But a global ocean even as shallow as 650 feet (200 meters) deep would have been detectable, the team remarks. Lakes of ethane could exist, they say, but they would have to be small and very shallow.

This outcome is surprising, given the relative durability of the global ocean hypothesis until now. But the radar results are, as Muhleman says, "robust," despite certain unknowns such as the conductivity of the surface materials and their roughness at radar wavelengths. The exact conditions lying beneath the haze, therefore, remain almost as mysterious as before. It will take an imaging radar — perhaps to be flown on the *Cassini* mission — to peel away the smog and reveal the Titanian surface as it really is. *Cassini*, however, won't reach the Saturn system until 2002.

TELESCOPES IN TEXAS AND CALIFORNIA

More than in any previous year, 1990 spring star parties in Texas and California focused on telescopes and technical innovations in electronics and photography. Due partly to poor weather and partly to the increasing sophistication of gadgets used by amateur astronomers, the Texas Star Party and the Riverside Telescope Makers Conference primarily offered a chance to see the latest in amateur equipment.

Over 650 amateur astronomers mainly from the central part of the country streamed into Fort Davis, Texas, for the Texas Star Party, held May 21-28. The observers brought with them dozens of telescopes, thirty-four of which were entered in the amateur telescope making judging. (There were no ranked prizes; rather, eight telescopes received equal merit awards.) The judges were Ken Drake, Buster Wilson, and Bill Krell, all of the Houston Astronomical Society.

The most spectacular telescopes shown were 6-inch and 4.25-inch binocular telescopes built by Houston-area amateur Peter Wraight. Each of these scopes features vertically stacked tubes made from PVC and painted wood, with eyepieces mounted along the tube's long axis on top of the upper tube. Additionally, Wraight designed and manufactured a collection of cardboard disks containing the positions of a Messier object and two bright, nearby stars. When a disk is placed in the telescope's tube on a special holder and oriented to match the sky, the position of the M-object is projected into a finderscope prism on the tube that allows the user to find M-objects instantly.

Peter Smitka of Brookfield, Wisconsin, brought a state-of-the-art Dobsonian. Smitka's 17.5-inch f/4.5 reflector has aluminum strut construction that allows it to be broken down into pieces that fit into a 40" by 48" trailer Smitka tows with a Honda car. Smitka included practically every conceivable luxury feature: The ground box has wheels that allow easy movement if the telescope needs to be repositioned; the 18-point mirror cell has a fan for fast cooling; the focusing is electric; one LED illuminates the secondary mirror for collimation, and another illuminates a holder for star charts; all adjustment bolts are secured by lock nuts; the finderscope has a heated dewcap; and the scope has its own digital clock.

More traditional Dobsonians constructed by Ken Drake and Barbara Wilson of Houston offered grand views of deep-sky objects during the week's rare, short-lived clear skies. Drake's 24-inch f/5.6 scope, dubbed "Vertigo 1," is constructed with the traditional aluminum-strut tube. Wilson's 20-inch f/4 reflector is an aluminum-strut Dobsonian that sits on a "polar roller" drive that tracks the scope for one hour by turning a steel shaft against a steel plate.

Other amateurs displayed ingenuity with accessories and devices. Ron Evans of Fort Worth and Byron Rogers of Austin each brought impressive binocular chairs and let viewers enjoy a comfortable seat with built-in optics. Joime Rueda of McAllen, Texas, showed his illuminated chart holder, a box with red-filtered fluorescent lights mounted on a camera tripod. Rueda pokes holes in X-ray film to make star charts that offer glowing star backgrounds. Houston's Steve Linscott and Olin Atkinson of the Texas Astronomical Society of Dallas brought observing boxes. These kits included illuminated, red-filtered star chart tables, storage for maps and charts, and even radios.

Telescopes weren't the sole attraction, however. Talks at TSP this year ranged from equipment and techniques for amateur astronomy to the latest word on the *Hubble Space Telescope*. Tony Hallas of Oakview, California, presented his techniques for color astrophotography and dazzled the audience with a 20-minute slide show set to music. Brian Marsden, director of the Central Bureau for Astronomical Telegrams in Cambridge, Massachusetts, spoke on amateurs and their role in the discovery of comets, asteroids, and novae. Ray Villard of the Space Telescope Science Institute provided an overview of *HST*'s deployment, operational procedure, and first images. Deborah Byrd, producer of the Star Date radio program and ASTRONOMY columnist, spoke on extrasolar planets.

The gathering finished with an ex-

TWENTY-FOUR-INCH "VERTIGO 1" and owner Ken Drake wait patiently for clear, dark skies at the 1990 Texas Star Party. Photo by David J. Eicher.

RIVERSIDE ENTHUSIAST Bob Goff shows his lightweight 24-inch mirror blank at the 1990 Riverside Telescope Makers Conference in Big Bear, California. Photo by Richard Berry.

traordinary talk by Walter Scott Houston, dean of deep-sky observers and for many years columnist for *Sky & Telescope* magazine. Houston spoke on deep-sky test objects, explaining how the tests have changed with the proliferation of better and larger telescopes and more accurate information over the past fifty years.

Observers at the Riverside Telescope Makers Conference, held May 25-27 at Big Bear, California, got a preview of where deep-sky observing and photography may be going in the 1990s with the new generation of low-cost CCD cameras. Several teams of amateurs set up telescopes with CCD imagers and computers. They amazed some of the estimated 2,500 people in attendance with "live" detailed images of favorite deep-sky targets and faint challenge objects. Throughout the two clear nights of the Riverside conference, groups of people huddled around glowing television monitors at various CCD setups watching the latest images appear on the screens.

One CCD camera that attracted a lot of attention was assembled by Kevin Medlock, Vance Chin, and Ron Story, all from the San Francisco area. They had an 8-inch f/3 Newtonian and an 8-inch f/1.5 Schmidt camera, mounted in tandem on a computer-controlled Epoch Instruments mount and each equipped with a water-cooled 512x486 pixel Philips CCD. Once they got this complex array of hardware and control software running, it was able to produce dramatic "wide field" images, including some detailed shots of Comet Austin showing a stubby fan tail and a faint spiky anti-tail. Visitors to the setup were also entertained with replays of images recorded earlier that night and stored on one of their computers' hard disks.

During the day, Chin set up a computer and monitor inside the exhibit room allowing those who went to bed early the night before to see what they'd missed. It was an unusual form of vicarious deep-sky observing.

While many of the talks at Riverside dealt with more traditional topics, the audience got a taste of the electronic revolution when Steve McArthur of SpectraSource Instruments used his CCD camera to capture live images of audience members in the darkened hall using exposures of only a fraction of a second. In another talk, Father Ronald Royer, whose photographs have appeared many times in ASTRONOMY, showed impressive television images of Jupiter taken through a 16-inch telescope with a home video camera.

However, if there was a theme to the lecture program at Riverside this year, it was "discoveries in the outer solar system." James Christy told the story of his discovery of Charon, the moon of Pluto; and John Bortle, the renowned comet observer, reviewed the greatest comets of the last few hundred years. Speakers also included a favorite of Riverside audiences, Clyde Tombaugh, the discoverer of Pluto, Brian Marsden, who visited Riverside after his stay at the Texas Star Party, gave conference-goers a behind-the-scenes look at how the Central Bureau for Astronomical Telegrams announces news of astronomical discoveries to the world.

It was a well-timed talk, since the bureau had just officially announced that David Levy had discovered his sixth comet only days earlier. At Riverside, observers got their first look at Comet Levy and were then able to chat with David in person the next day.

It is this kind of interaction that makes star parties like TSP and Riverside so memorable. If you haven't been to one yet, be sure to include a star party in your plans for next year.

Space News

NASA JUGGLES LAUNCH SCHEDULE

The delay last May in the launch of *Columbia* with the *Astro-1* mission forced NASA to do some quick reshuffling of the shuttle launch schedule for the rest of 1990. The missions affected are the ones set to fly on *Columbia*, including two major *Spacelab* missions, the Life Sciences Laboratory and the International Microgravity Laboratory. The Life Sciences Lab, originally planned for August, is now slated for a December launch, while December's Microgravity Lab mission will wait until 1991, provided *Astro-1* and *Columbia* fly in mid-August as currently planned.

NASA hopes to keep the flights of the other two orbiters, *Atlantis* and *Discovery*, on schedule. This includes an October 5 launch date for the *Ulysses* mission on board *Discovery*. *Ulysses* is the long-awaited probe to explore the polar regions of the Sun. It was originally scheduled for launch in late 1986. Since its flight path takes it past Jupiter, the timing of the launch is critical. If *Ulysses* does not get on its way before October 23, it faces another 13 months on the ground waiting for the next time Jupiter and Earth come into the correct alignment. One possible problem occurred in early June when a cable hanging from an overhead service crane accidently bent a *Discovery* payload bay door about twelve inches. NASA officials felt that the damage was minor and would not hold up the *Ulysses* launch preparations.

The other major space science mission this year, the *Gamma Ray Observatory*, should also be unaffected by the *Columbia/Astro-1* delays. It is still set for a November 1 launch on *Atlantis*. However, that date depends on whether *Atlantis* completes its Department of Defense mission on schedule in July.

GIOTTO'S CAMERAS BLINDED

Earlier this year the European Space Agency's *Giotto* comet probe was switched on after a four-year hibernation and put through its paces. ESA technicians wanted to see if *Giotto* was functioning properly for its proposed encounter with Comet Grigg-Skjellerup in July 1992. (See "*Giotto* Reactivated for New Mission," Space News, July 1990.) Initial tests indicated that the battered spacecraft had survived its Halley encounter in surprisingly healthy condition. However, subsequent tests later in the spring revealed that the camera system does not appear to be functioning. While dust from the Comet Halley encounter has badly damaged the optics, the main problem appears to be a dislodged light baffle that is blocking the camera's vision. According to ESA spokesman Roget Elaercs, "We hope something might get through, but at the moment we don't expect the camera will be useful during the Grigg-Skjellerup encounter." ESA will decide this autumn whether to go through with the mission. As Elaercs said, "The funding has been approved, and with a number of other instruments working we will likely go ahead despite the failure of the camera." □

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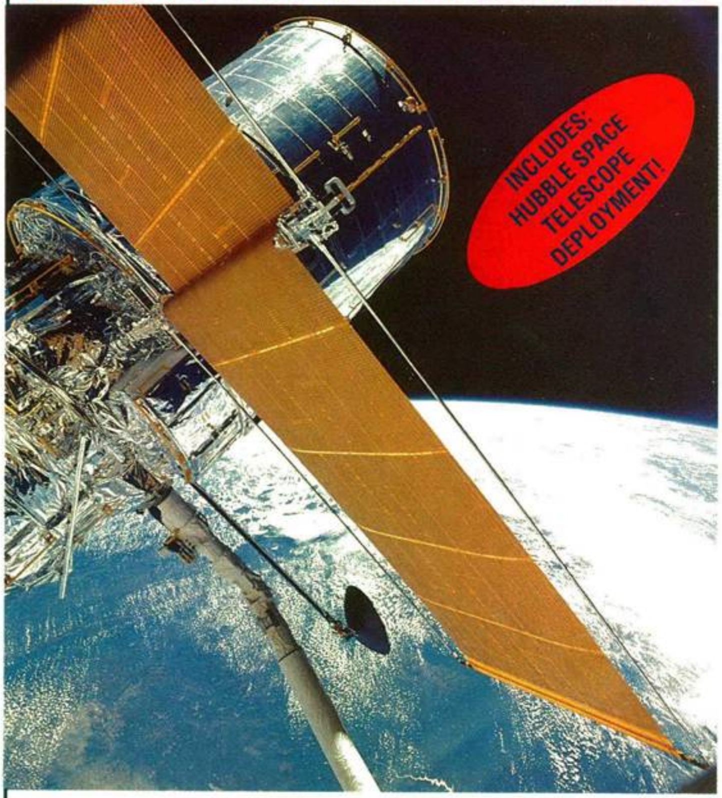

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For any alt-azimuth (Dobsonian) scope	**$498**
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The **LUMICON SKY VECTOR II™** has all the features of the regular SKY VECTOR, but has 1000 of the best deep-sky objects in memory along with their coordinates, size, magnitude, and other descriptive data. The sophisticated computer programming also will guide you to the object selected by displaying the real-time angular separation. Just move the telescope until the angles displayed become "0" using the "GUIDE" mode.

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- All 110 Messier objects
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- 430 galaxies, groups & clusters
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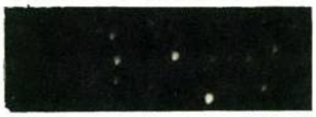
COMA CORRECTOR



Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces.

LUMICON Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER	**$169.50**
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2080 Model 30, 8" f/10	**$1450**
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2120 Model 30, 10" f/10	**$1850**
2120 Model 36, 10" f/6	**$2298**

Options Enhance Performance

Super Wedge for 10"	**Add $295**
Dual-axis handbox controller	**Add $119**
Declination motor	**Add $109**
Digital setting circle	**Add $399**
2" Star diagonal	**Add $179**
LUMICON Cassegrain Easy-Guider *(Please specify camera)*	**Add $225**
LUMICON Giant Easy-Guider (for #30) *(Specify camera)*	**Add $395**
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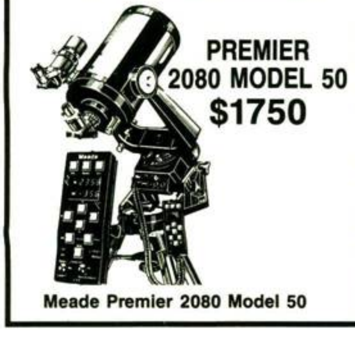

Meade Premier 2080 Model 50

MEADE SERIES 4000 EYEPIECES

Super Plossl: 6.4mm, 9.7mm, 12.4mm **$89** 15mm, 20mm, 26mm **$89; 32mm $109**
Super Wide-angle: 13.8mm **$129,** 18mm **$135,** 24.5mm **$149,** 32mm (2") **$219**
Ultra Wide-angle: 4.7mm **$149,** 6.7mm **$179,** 8.8mm **$209,** 14mm **$249**

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2045D 4" f/10 w/motor drive	**$695**
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2080 Model 50, 8" f/10	**$1750**
2120 Model 50, 10" f/10	**$2195**
2120 Model 50H, 10" f/10 w/Super Wedge	**$2395**
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Dew shield - essential! 8" **$65;** 10"	**$98**
LUMICON EASY-GUIDER for 2080	**$225**
EASY-GUIDER (f/4-f/10) for 2120	**$395**
CAT command control, 8200 objects	**$999**

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MTS-SN6, 6" f/5, #788 drive	**$649**
MTS-SN6 w/drive, MCOG	**$698**
MTS-SN8, 8" f/4 w/drive, MCOG	**$795**
MTS-SN8, 8" f/4 w/LX3 drive, MCOG	**$1048**
#36 LX3 hand cntrl. & #38 dec. motor	**$189**

NEWTONIAN

Model 826C 8" f/6 w/motor, 2" focuser	**$898**
Model DS-10A, 10" f/4.5 w/mtr., 2" focus.	**$975**
Model DS-16A, 16" f/4.5 w/motor, 2" focuser	**$1975**
Model DS-16A w/Sealmaster ball bearings for photography	**$2195**
8X50mm finderscope w/brackets for DS-10 or DS-16	**$109**

1.8x MULTIPLIER LENS

1.8x Multiplier Lens

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. Guide-stars also become much sharper to make guiding easier. This lens is optimized for f/4.5, but will work well with any optical system. It may also be used visually as a highly corrected 2" Barlow lens.

LUMICON 1.8x multiplier lens	**$235.00**

NEW! LOW PROFILE HELICAL FOCUSERS

FROM $49.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	**$49.50**
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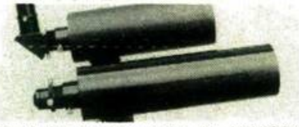
2" LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra. The

1¼" 50mm Finderscope **$59.50**, right-angle	**$89.50**
1¼" straight-thru 80mm SUPER-FINDER	**$169**
1¼" right-angle 80mm SUPER-FINDER*	**$179.50**
1¼" right-angle version, w/star diagonal	**$209**
25mm Cross-hair 1¼" eyepiece (12X)	**$29**
*1¼" Star Diag. **$32**, 2" Star Diag., silver,	**$159**
1¼" Amici Prism diag. for correct left-right views	**$69.50**

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These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

2" adapter for C-8, Meade 2080, etc.	**$26.00**
2" adapter for C-80, C-100 refractor	**$39.50**
2" adapter for C-70, C-80F, C-90F, C-100F	**$39.50**
2" Accessory adapter for Comet Catcher*, C-6*, Meade 310, 320 refractor	**$30.00**
2" adapter for Takahashi E-130, 160	**$59.50**

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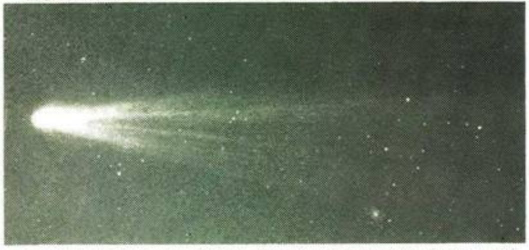
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

LUMICON FILTERS HELP FIND A COMET



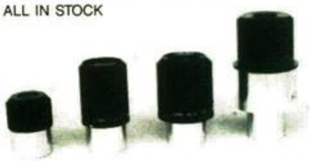
Comet Aarseth-Brewington 1989a1, discovered by Howard Brewington ***using a 48mm LUMICON Swan Band Comet Filter!*** "The filter doubled contrast, making the comet very easy to spot," said Mr. Brewington. His 60 second photo on hypered 2415 (8" f/1.5) shows a nice tail.

20mm NAGLER

Also new 12mm & 16mm NAGLERS

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK



Oracle 3" f/7.4 Triplet Apochromat	$750
Genesis 4" f/5.5 Fluorite Apochromat	$1450
Renaissance 4" f/5.5. Telescope	$1450
7.4, 10.4, 13, 17, 21, 26mm Plossl, 50°	$89
1.8X or 2.5X Tele Vue Barlow Lens	$89
32mm Plossl, widest true field in 1¼"	$109
55mm 2" Plossl, widest possible field	$219
15mm Wide-Field, 1¼" eyepiece, 65°	$135
19mm Wide-Field, 1¼" eyepiece, 85°	$145
24mm Wide-Field, "superb," 65°	$169
32mm Wide-Field, 2" eyepiece, 65°	$239
40mm Wide-Field, "awesome," 65°	$299
4.8mm Nagler, 82° field	$149
7mm Nagler, 1¼" eyepiece, 82° field	$189
9mm Nagler, 82° field, "the best"	$219
11mm Nagler, 82° field, 1¼" or 2"	$235
13mm Nagler, 82° field, 1¼" or 2"	$249
12mm Nagler, Type II, 82°, 1¼"/2"	$249
16mm Nagler, Type II, 82°, 1¼"/2"	$289
20mm Nagler, Type II, 82°, 2" only	$340

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.

LUMICON Adjust. Piggyback Mount .. **$54**
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	**H-Alpha**	**(MV)**
46, 48, 49mm	**$47.00**	**$39.00**
52, 55, 58, 62mm	**$59.00**	**$49.00**
67, 72, 77mm	**$69.00**	**$59.00**
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Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. 1.3-1.8" mirrors have enhanced silver coatings (98-99%R). The extra 8-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$29.95**	1.52"	**$34.50**	1.83"	**$39.50**
2.14"	**$49.50**	2.60"	**$65.00**	3.10"	**$89.50**
4.25"	**$149.50**	4.00"	**$149.00**		

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm. Transmission = 90-97%.

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter or the LUMICON UHC Filter**

"I CAN SEE THE OWL NEBULA!"
Tom Kramer saw the Owl Nebula, M-97, for the first time using a LUMICON UHC Filter. He stated, *"I had never seen M-97. . . I attached the UHC Filter and tried again. M-97 was right there. I could not believe it! The UHC Filter should be standard equipment."*

Tom Kramer, Sayville, NY

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 85-95%. Visible transmission = 85-95%.

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	**$59.50**
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	**$79.50**
48mm LUMICON DEEP-SKY Filter (1.75" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	**$119.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$119.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)	**$299.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$199.50**
Set of Both premium **DEEP-SKY** and **UHC Filters** (Save 11%), Premium	**$159.50**
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** **$99.50, 48mm**	**$199.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines **1¼" $99.50, 48mm**	**$199.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	**$20.00**

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$350**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$65**

Electric Vacuum Pump, Model R-10 **$295**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
Specify Camera and Telescope type.

U.S. Patent 4,448,500

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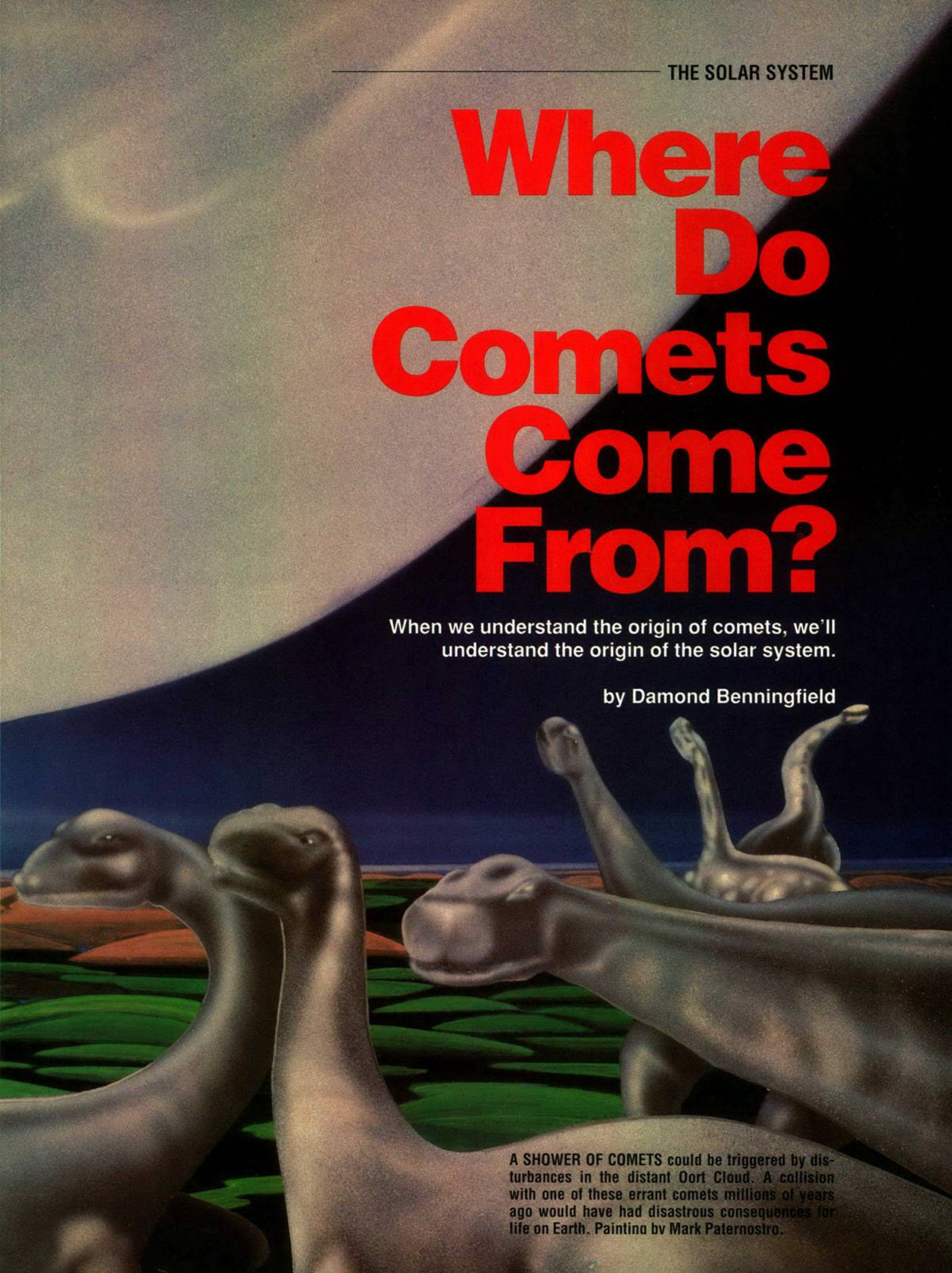
Where Do Comets Come From?

When we understand the origin of comets, we'll understand the origin of the solar system.

by Damond Benningfield



A SHOWER OF COMETS could be triggered by disturbances in the distant Oort Cloud. A collision with one of these errant comets millions of years ago would have had disastrous consequences for life on Earth. Painting by Mark Paternostro.

It would have been a strange scene. A quiet sunset. The distant cry of a dinosaur. And a twilight sky filled with ghostly apparitions — comets.

We can't imagine such a cometary spectacle occurring today, nor would we want it to. Prehistoric comet showers, when tens or hundreds of comets orbited through the inner solar system at once, might have brought death to Earth. Our dinosaur bellowing in the distance would have been witnessing the agents of its own destruction.

The impact of a comet on Earth could have changed the course of evolution. Sixty-five million years ago, such an impact could have caused the demise of the dinosaurs, though the theory is still controversial.

Ironically, though, comets may also prove to be bringers of the staples of life. A steady rain of carbon-rich comets — 100,000 in the first billion years after Earth formed — could have provided organic molecules as "manna" from heaven. In addition, because comets contain so much water ice, they also may have supplied much of the water in Earth's oceans, another critical ingredient in the primordial soup from which life evolved.

It appears that understanding comets may be a key to understanding the evolution of Earth. But where do comets come from? What could unleash a rain of comets?

In searching for the answers, astronomers have increased their estimates of the number of comets lurking out there — to perhaps tens of trillions — and have refined their theories of how comets are distributed in the darkness at the edge of the solar system. It now appears that how comets got there is a critical part of the processes that form solar systems. Indeed, comets may be relict planetesimals left over from the accretion of the planets 5 billion years ago. Said Anita Cochran, an astronomer at the University of Texas at Austin, "When we understand comets, we will also understand the origin of the solar system."

Into the Deep Freeze

Since the early 1980s when Comet Halley was first sighted on its last passage around the Sun, cometary research has become a more active field. "There's much more research [today] than there was pre-Halley," said Paul Weissman, deputy project scientist for the upcoming *Comet Rendezvous/Asteroid Flyby (CRAF)* mission. "[Halley] brought a lot of people into the field." The result has been a great deal of work refining the precise mechanisms that formed comets and placed them in the outer reaches of the solar system.

The classic picture of how the solar system formed goes something like this: The process began with an interstellar cloud of gas and dust a light-year or more in diameter. Gravitational attraction caused the cloud to contract and form a flattened, spinning disk called the solar nebula. The Sun formed at the center of the nebula, where the density of the cloud was greatest. Outside the rapidly collapsing protosun, material congregated in spiral arms, where it coalesced into small chunks of rock and ice. More and more pieces accumulated until they formed planetesimals — chunks of matter as large as a few kilometers across — which in turn collided and stuck together to form even larger objects — the planets.

The Sun heated the inner regions of the nebula, vaporizing ices in the planetesimals and leaving only dense, rocky cores — the seeds for Mercury, Venus,

Comets may be relict planetesimals left over from the formation of the planets.

BILLIONS OF YEARS AGO many planetesimals may have been flung far from the Sun to form clouds of comets. We may be seeing evidence of similar debris clouds around other stars, such as the disk of material detected around Beta Pictoris (right). Painting (above) by Paul Hudson. Beta Pictoris image courtesy of the University of Arizona and the Jet Propulsion Laboratory.

Earth, and Mars. But in the outer reaches of the nebula, the young star's heat was insufficient to blast away the hydrogen, methane, and other volatile materials. In those colder regions, planetesimals retained their ices. The planets that grew from them became gas giants, and their moons became ice worlds.

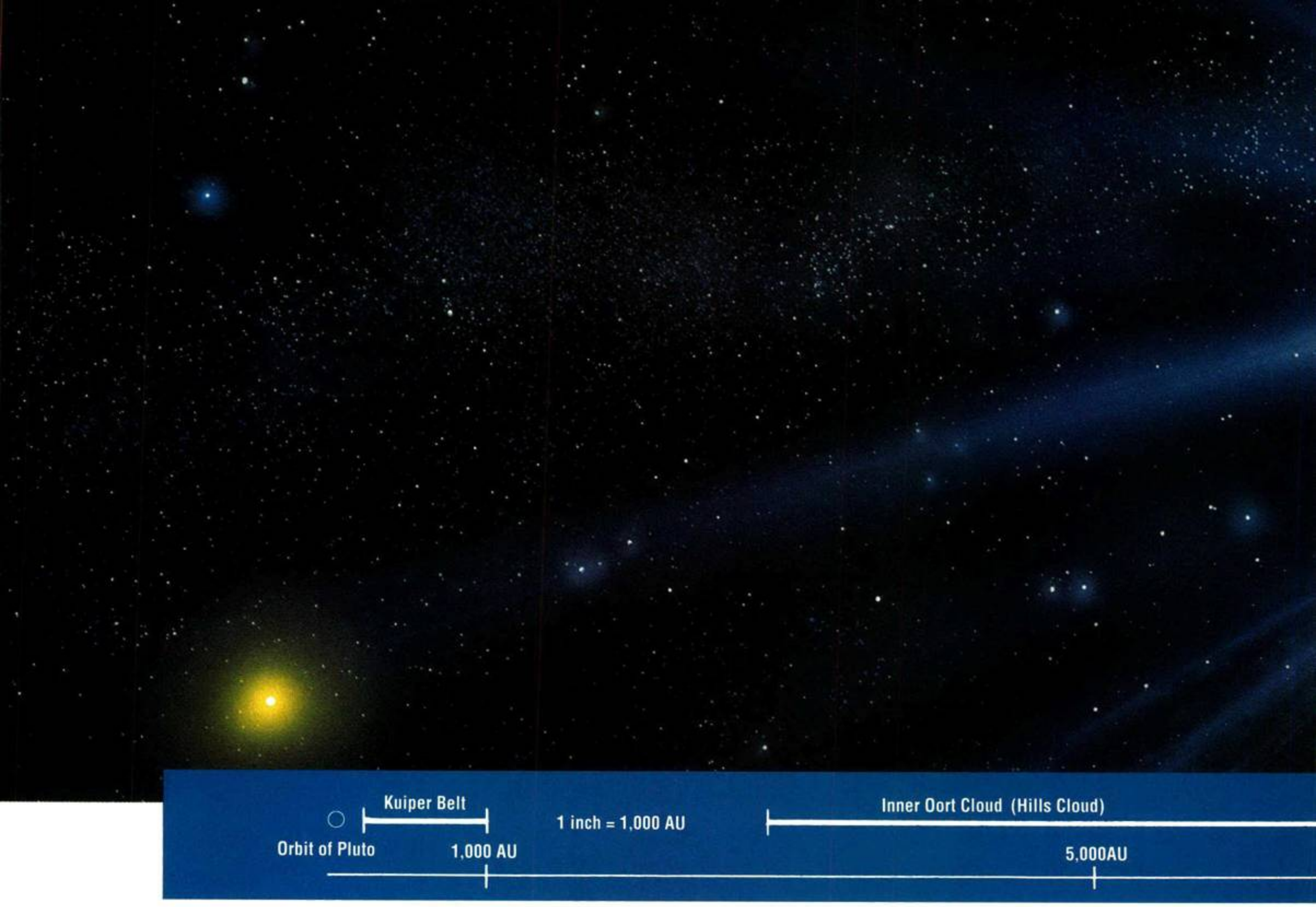
But here's where the comets come in. Not all of the icy planetesimals were devoured by the growing gas giant planets. Some were hurled far outside the region of the planets by the powerful gravitational fields of the gas giants. Planetesimals passing near the largest planets, Jupiter and Saturn, were ejected from the solar system entirely. Those passing near the weaker gravitational fields of Uranus and Neptune remained gravitationally bound to the Sun but were tossed into orbits that carried them thousands of astronomical units (AU) away.

In 1950, Dutch astronomer Jan Oort proposed that the latter group of planetesimals still exists, forming a spherical shell (now called the Oort Cloud) that surrounds the solar system. Oort's proposal was based on calculations of the orbits of long-period comets (those with orbital periods of 200 years or longer), which come from all directions in the sky and not just near the plane of the solar system.

Oort determined that comets tossed into highly elliptical orbits by Uranus and Neptune would be nudged into more nearly circular orbits by encounters with passing stars. Stellar encounters also would scatter comets above and below the ecliptic plane, creating a sphere of comets instead of a flattened disk. After four decades of refinements to Oort's original ideas, astronomers today believe the Oort Cloud extends from about 20,000 to 100,000 AU (almost 2 light-years) from the Sun and contains as many as two trillion comets with a total mass several times Earth's.

Alien Oort Clouds

No one has seen the Oort Cloud, of course. Its member comets are so small, dark, and far away that present-day astronomical instruments cannot detect



them. But there may be ways to detect the Oort Clouds around other stars.

The University of Colorado's Alan Stern, Michael Shull, and John Brandt have suggested that the existing evidence for water and other volatile molecules in the regions around giant stars may in fact be signs of comet clouds around these aging, bloated stars. As stars expand and grow more luminous late in their lives, they gradually vaporize whatever icy material might be orbiting in their alien comet reservoirs. The researchers propose that we may be seeing this process happening now around some red giant stars.

There is other evidence to suggest that comet clouds are more than just theory. In 1983 the *Infrared Astronomical Satellite (IRAS)* discovered faint shells or disks of dust around Vega and several other stars. Later, Richard Terrile of the Jet Propulsion Laboratory and Bradford Smith of the University of Arizona photographed a disk of material around the star Beta Pictoris, 54 light-years from Earth. The disk extends several hundred AU from Beta Pictoris and its total mass may be several hundred times that of Earth.

Although both *IRAS* and the subsequent ground-based observations detected only dust clouds, the Jet Propulsion Laboratory's Paul Weissman notes that there must be a source, probably planetesimals, to replenish the dust. If so, then the observed dust disks may mark the comet clouds of other stars. The reason we can detect these distant clouds, if that is indeed what they are, and not our own is that our solar system's Oort Cloud is spread over the entire sky.

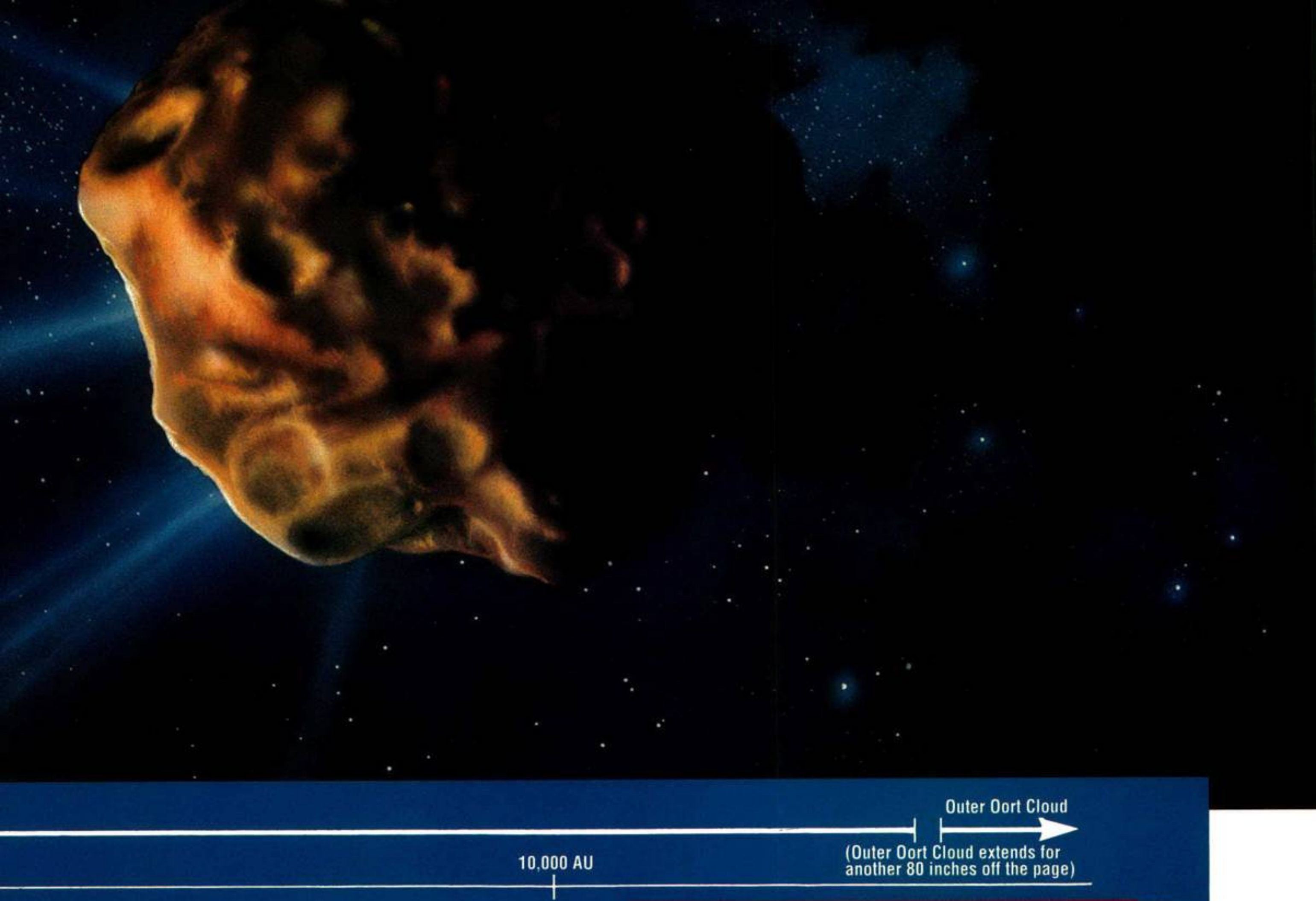
Return to the Sun

Once a comet finds its way into the Oort Cloud, something must give it a good push to send it back into the realm of the planets. Oort determined that passing stars can provide that push.

The gravitational attraction between the Sun and Oort Cloud comets is quite weak, so that a star passing within a few light-years of an Oort Cloud comet could tug on the tiny body enough to change its velocity. Weissman noted that about 5,000 stars may have passed within 100,000 AU of the Sun over the lifetime of the solar system. With enough stellar encounters a comet could either be stripped from solar orbit and lost to interstellar space or robbed of enough energy to send it plummeting toward the Sun.

More recently, astronomers have suggested that other objects also could deflect Oort Cloud comets. For example, we now know that giant molecular clouds populate our galaxy's spiral arms, clouds that were unknown when Oort created his model of the cometary reservoir. As the Sun orbits the Galaxy it might pass through these interstellar clouds every few hundred million years, in turn stirring up the inhabitants of the Oort Cloud and sending them Sunward.

Another newly discovered agent for perturbing Oort Cloud comets is gravitational tides. Created by the gravitational force of material in the Galactic disk, these tides could alter the orbits of Oort Cloud comets. In fact, some astronomers estimate that as many as 80


Outer Oort Cloud
(Outer Oort Cloud extends for another 80 inches off the page)
10,000 AU

COMETS ARE LOCATED in three main zones: the Kuiper Belt closest to the Sun, the inner Oort Cloud (also called the Hills Cloud), and the outer Oort Cloud. The distances of these zones from the Sun are shown on a scale of one inch = 1,000 AU. On this scale the diameter of Pluto's orbit is a mere 1/10th of an inch. Painting of molecular cloud encounter (above) by Paul DiMare .

Encounters with giant molecular clouds could stir up the inhabitants of the Oort Cloud and send them Sunward.

percent of the long-period comets entering the inner solar system for the first time were shoved from their previous orbits by the gentle tug of Galactic tides.

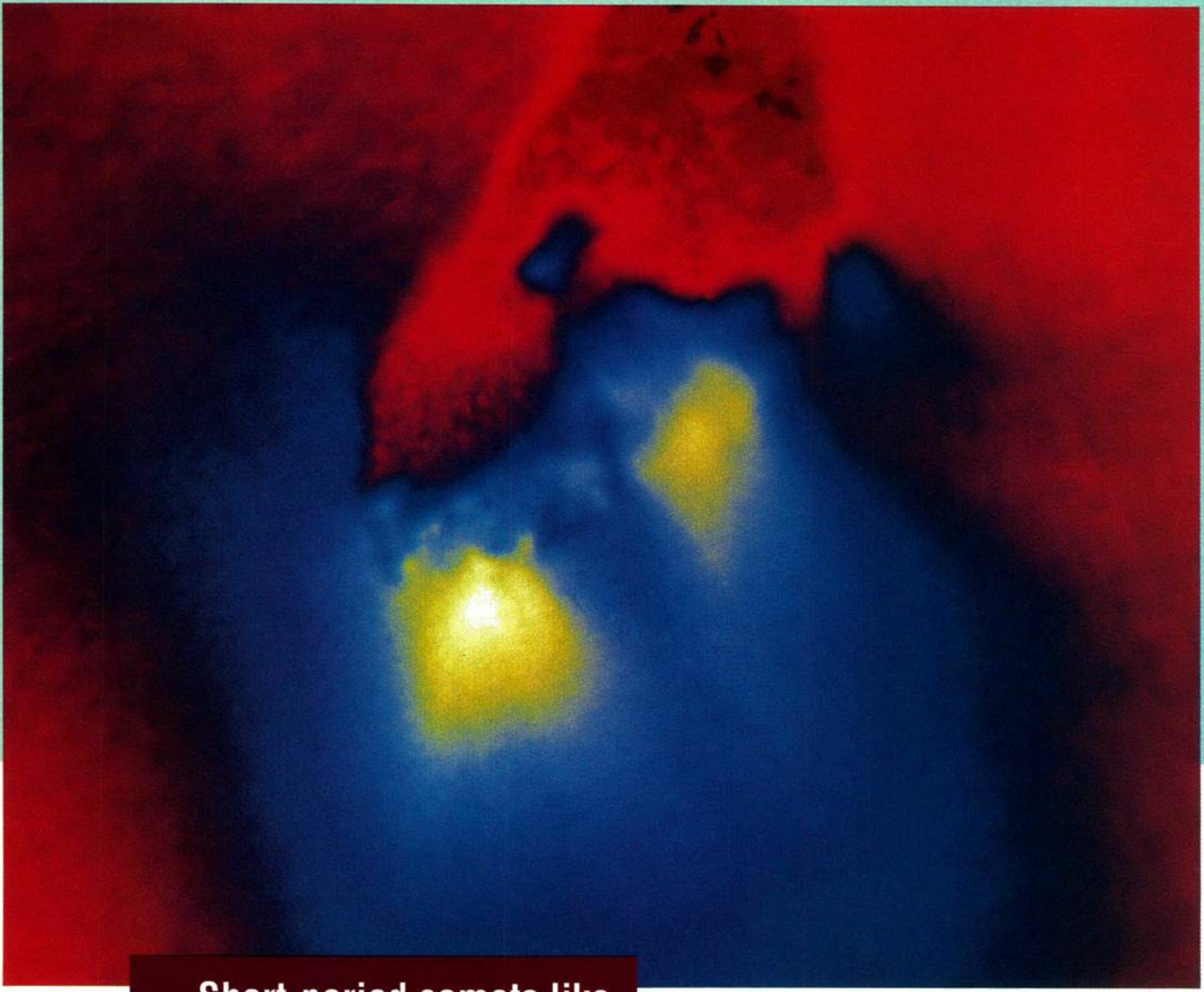
Stocking the Oort Cloud

Oort's model was accepted as the definitive description of cometary distribution for more than three decades. Recent calculations have shown, however, that the life expectancy of a comet in the outer Oort Cloud is only about 3 billion years, two-thirds the age of the solar system. As a result, all the comets should have disappeared long ago — unless, of course, there is a source of new comets to replace those lost.

During the 1980s, astronomers realized that Oort Cloud comets may be outnumbered by an inner cloud that begins about 3,000 AU from the Sun and continues to the edge of the classical Oort Cloud at 20,000 AU. Most estimates place the population of the inner Oort Cloud at about five to ten times that of the outer cloud — say, 20 trillion or so — although the number could be ten times greater than that. The innermost portion of the inner Oort Cloud is relatively flattened, with comets extending a few degrees above and below the ecliptic. But the cloud rapidly expands, forming a complete sphere by the time it reaches several thousand AU.

According to a model proposed by three Canadian astronomers, Thomas Quinn of Oxford University, Martin Duncan of Queen's University, and Scott Tremaine of the Canadian Institute for Theoretical Astrophysics, the inner Oort Cloud (sometimes called the Hills Cloud, in honor of astronomer Jack Hills, who proposed its existence in the early 1980s) formed first. Unlike their more distant siblings, comets in the inner cloud are tightly bound to the Sun, so passing stars and Galactic tides don't perturb their orbits enough to force them back into the planetary region.

Occasionally, though, a star or giant molecular cloud passes directly through both Oort Clouds, scattering comets like a cue ball striking the neatly racked



COMET HALLEY'S NUCLEUS as seen by *Giotto*, courtesy of the Max-Planck-Institut für Aeronomie.

Short-period comets like Halley come from a zone just beyond the planets called the Kuiper Belt.

balls on a billiard table. Such an event kicks many comets into the outer cloud, replenishing those lost to other processes. Such an encounter could also deflect many comets toward the Sun, creating comet showers that last for several million years. During these showers, the number of comets entering the planetary region could be many times the average rate, increasing the chances of collisions with Earth.

For many years, astronomers believed that all comets observed in the inner solar system came from the distant Oort Cloud. Short-period comets (those with orbital periods under 200 years, such as Halley) were believed to have started as Oort Cloud denizens whose orbits were altered by encounters with the giant planets.

Today, though, it appears that short-period comets come from yet another cloud beyond the planets: the Kuiper Belt.

Quinn, Duncan, and Tremaine ran computer simulations of the orbits of two kinds of comets, those captured from the distant Oort Cloud *and*those coming from a proposed belt of comets much closer to home. They found that for short-period comets an origin in a flattened ring just beyond the orbit of Neptune fits the evidence best. For one thing, the orbits of most short-period comets lie within a few degrees of the ecliptic plane. If they had come from the spherical Oort Cloud their orbits should be randomly distributed in all directions and orientations.

According to the Canadian astronomers, the Kuiper Belt (named in honor of Gerard Kuiper, who first speculated on the possibility of such a region in 1951) begins about 35 to 40 AU from the Sun and may extend as far as several hundred AU. Estimates of the Kuiper Belt population range from about 100 million to a few billion. Unlike Oort Cloud comets, which formed in the region near Uranus and Neptune and then were propelled to extreme distances from the Sun,

Are Comets Interstellar Probes?

One reason astronomers are so interested in comets is that they may be samples of interstellar material — the stuff that formed the planets and that still exists in star-forming nebulae throughout the Galaxy.

In their Oort Cloud deep-freeze, comets may be affected only by passing stars and interstellar clouds. These agents can shove comets around and also alter their surface features and chemical compositions.

Interstellar molecules can stick to a comet's surface, adding a thin veneer of interstellar material to the pristine remnants of the solar system's formation. Impacts with heavier dust grains, on the other hand, erode the comet's surface. Alan Stern of the University of Colorado has calculated that several meters may have been scrubbed from the surfaces of comets in the Oort Cloud.

When the European *Giotto* probe passed just 600 kilometers from the nucleus of Comet Halley in 1986 and took photographs such as the one at left, its instruments detected several types of dust. One type of comet dust, dubbed "CHON" by Halley scientists, consists of carbon, hydrogen, oxygen, and nitrogen. The high percentage of carbon, which is about the same percentage as that found in stars in our galaxy, could indicate the presence of interstellar matter in the comet's surface layers.

The temperature in the Oort Cloud is about 10 kelvins (-263° C), sufficiently cold to freeze even the most volatile elements in place. But occasional close passages of extremely bright stars can heat the comets to a depth of a few meters, allowing some volatile elements to escape and increasing the relative abundance of water ice.

Stern and colleague Michael Shull have calculated that over the history of the solar system all comets should have been heated to 20 kelvins at least once, and there is about a one in ten chance that any given comet has been warmed to 30 kelvins by a passing star.

One other event could trigger a cometary warming trend: a supernova explosion within a few light-years of the Sun. For a few months, the supernova could heat the comets to 50 kelvins, penetrating a meter or so below the surface. "Fifty K isn't much warmer than [Neptune's moon] Triton, but Triton is the equivalent of Miami Beach for a comet," Stern said.

Although all of these processes alter a comet's surface, its exposed material "is still more pristine than anything we've seen on the Moon or Mars," Stern said. "But if you really want to see pristine material, you'll have to drill a hundred meters deep, not two meters. That's like North Sea drilling."

Kuiper Belt comets are believed to have formed in place beyond Neptune. The gradual pull of the giant planets accumulated over time brings the occasional Kuiper Belt comet in toward the Sun.

However, another possibility for disturbing the Kuiper Belt is the presence far beyond Neptune of very massive comets. If they exist, some of these supercomets could be large enough for astronomers to observe with Earth-based telescopes.

Searching for Kuiper Belt Comets

During late 1988 and early 1989 Martin Duncan, along with Harold Levison of the U.S. Naval Observatory, used the 40-inch telescope in Flagstaff, Arizona, to survey a small portion of the sky in search of Kuiper Belt objects. Comets within the belt would appear to change positions by 2 to 3 seconds of arc in an hour. Levison and Duncan took several images of each section of the sky and used a computer to search for objects that appeared to move with respect to the background stars.

They found nothing, although their instruments could detect only relatively large bodies — roughly the size of Chiron, an object about 200 kilometers in diameter circling the Sun between the orbits of Saturn and Uranus. Although astronomers originally thought Chiron was a large asteroid, they recently discovered a coma enveloping its surface, a key characteristic of a comet. (See "The Changing Face of Chiron," August 1990.) Chiron thus became the largest cometary body ever discovered.

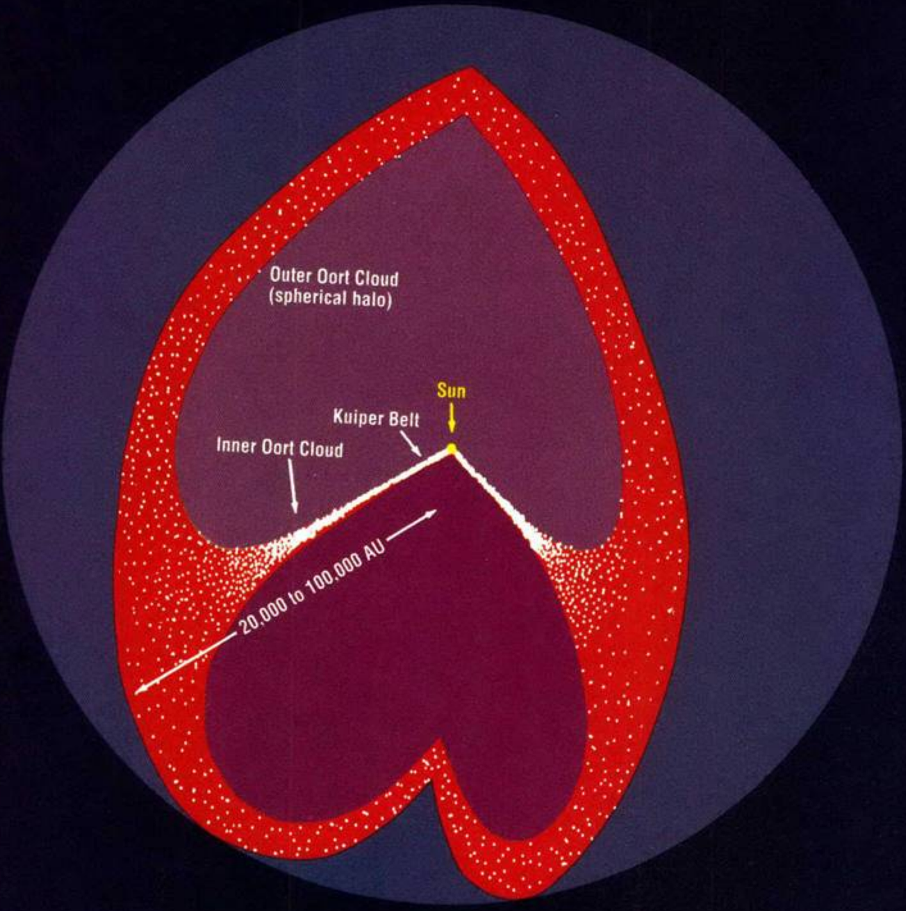
"Chiron probably originated in the Kuiper Belt and was influenced by the gravity of Neptune, which deflected it inward, and eventually the entire orbit moved inward," said Duncan. "It's in a chaotic orbit — you can't predict where it will go or where it came from. But it's the sort of object we could hope to detect." Levison added, "If not for Chiron, we wouldn't be interested in looking for Kuiper Belt objects. You could argue that all comets are less than 40 kilometers in radius, so you just can't see them. But because of Chiron, we suspect there must be larger objects."

Several astronomers hope to use larger telescopes, such as the 4-meter at Kitt Peak National Observatory or the 107-inch at McDonald Observatory, to hunt for Kuiper Belt objects. Astronomers at The Lawrence Livermore National Laboratory have announced plans to search for comets about 100 AU from the Sun by looking for stellar occultations. Based on current estimates of the comet population, they expect to detect 1,000 or so occultations a year.

During the coming decade, the pace of cometary studies could quicken even further. Other teams of astronomers will use the *Hubble Space Telescope* to conduct high-resolution observations of comets as they pass through the inner regions of the solar system. The European Space Agency also plans to reactivate the *Giotto* spacecraft for a flyby of Comet Grigg-Skjellerup in July 1992.

And if all goes well, on August 14, 2000, the *Comet Rendezvous/Asteroid Flyby* probe should begin its mission of flying in formation with Comet Kopff. It will spend a year photographing the nucleus, charting its temperature, and observing it spectroscopically. When Earthbound scientists have picked just the right spot, *CRAF* will fire a lance-shaped probe into the comet's nucleus.

All of this is setting the stage for an even more ambitious project sometime after the turn of the cen-



THE COMET RESERVOIR likely resembles a flat disk near the Sun (the Kuiper Belt) which gradually flares out through the inner Oort Cloud to become a spherical halo surrounding the Sun at a distance of tens of thousands of AU (the outer Oort Cloud). First-time cometary visitors, like Comet Austin (above), likely come from the flared region of the inner Oort Cloud. Illustration by Tom Hunt. Photo of Comet Austin by Michael Stecker.

The inner Oort Cloud expands from a disk to a complete sphere several thousand AU from the Sun.

tury: a mission to scoop a few kilograms of material from the surface of a comet and return it to Earth for laboratory analysis. Said Thomas Ahrens, chairman of the United States science definition team for the sample return mission, "Some material could be as old as the Galaxy."

The next few years should prove to be an exciting time for comet research. Learning what comets are made of and where they come from will be key goals of both Earth-based observations and space probes. Once ignored as mere solar system debris, comets now appear to hold the secrets to the origins of the planets, the Earth, and perhaps life itself. □

Damond Benningfield is a freelance science and technology writer living in Austin, Texas.

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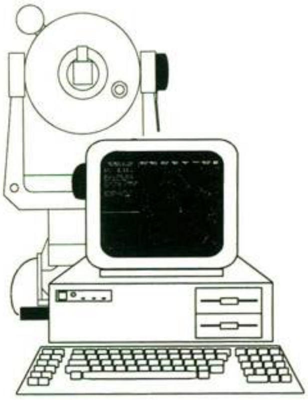

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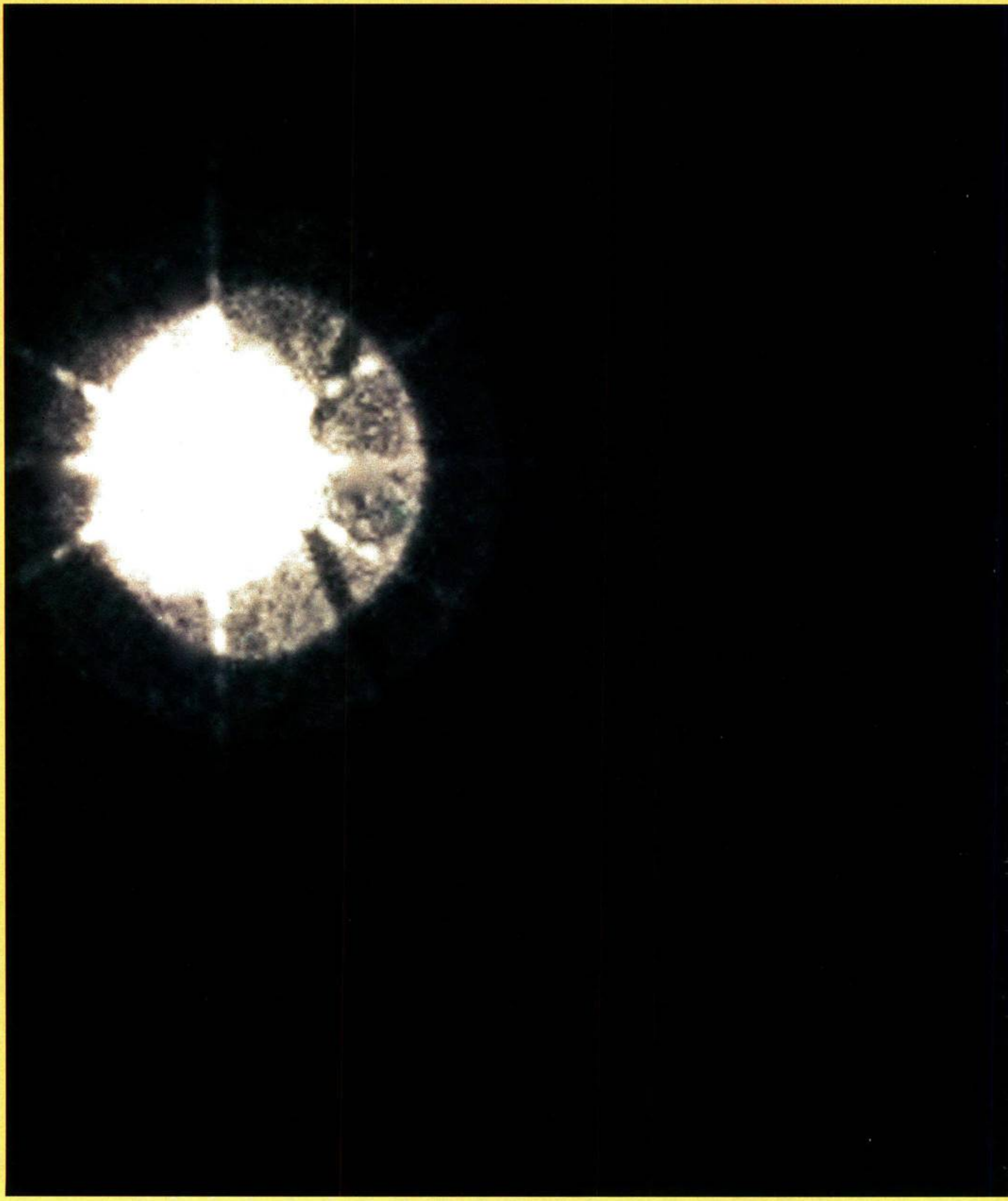
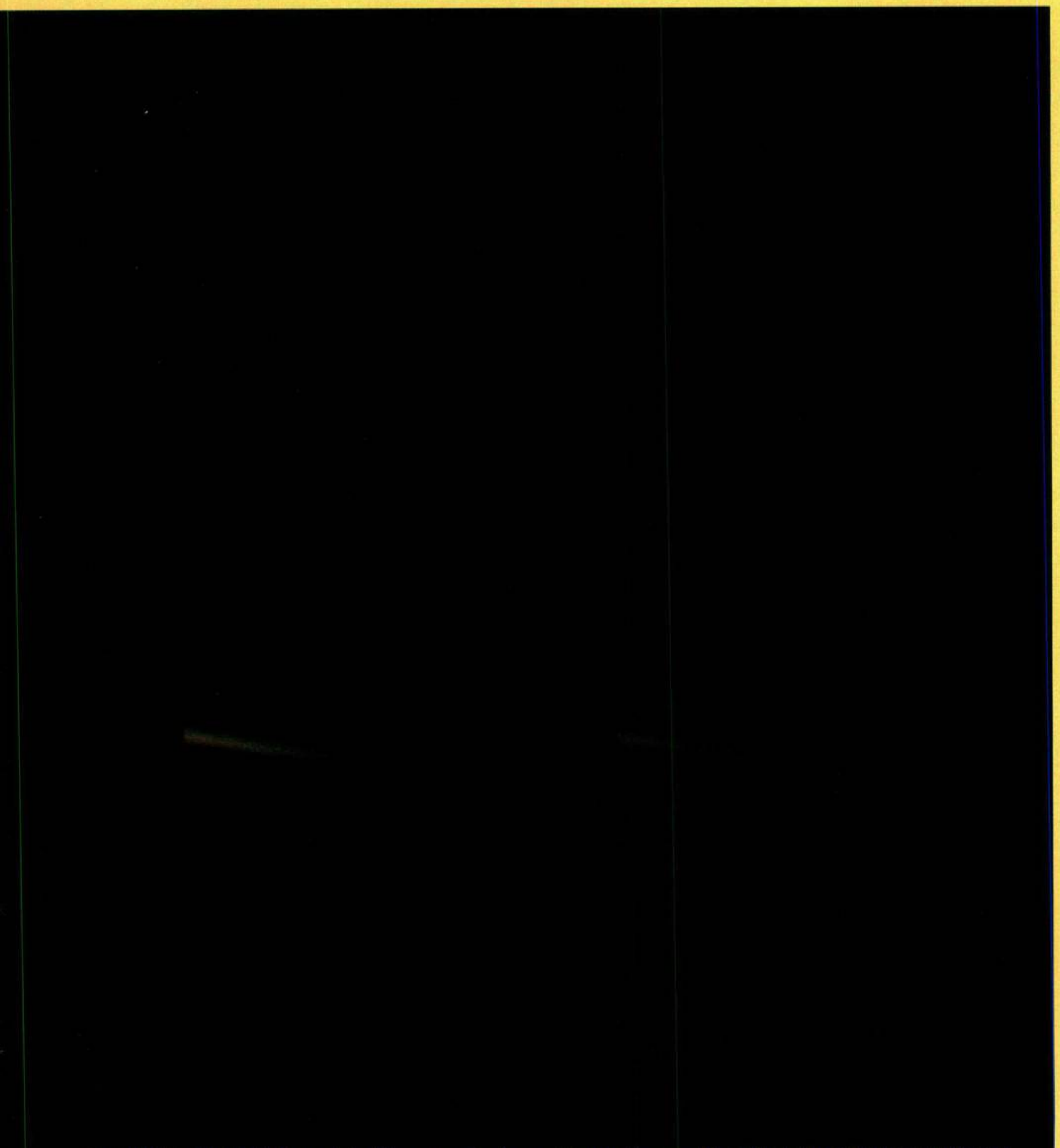


SOLAR SYSTEM EXPLORATION

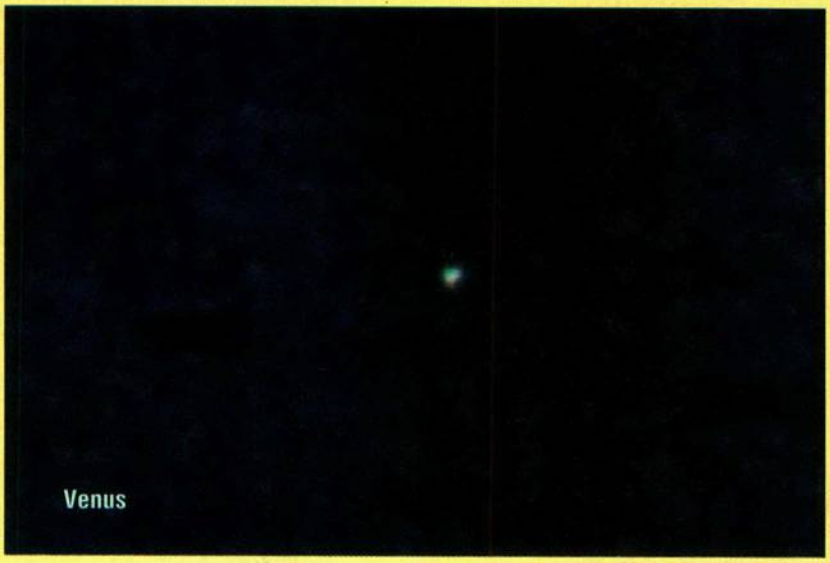
Voyager's Last Light



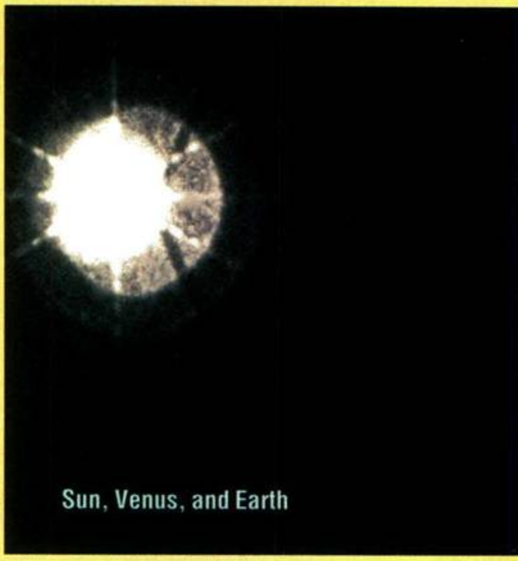
SUN, VENUS, AND EARTH posed for this composite image taken by *Voyager 1*'s wide-angle and narrow-angle cameras on February 13, 1990. The Sun (left) is greatly overexposed due to its great brightness; Venus (left) and Earth (right) were imaged with the narrow-field camera and inset into the mosaic. NASA photo.

From a distance of 3.7 billion miles, Voyager 1 snaps an historic family portrait of the Sun and planets.

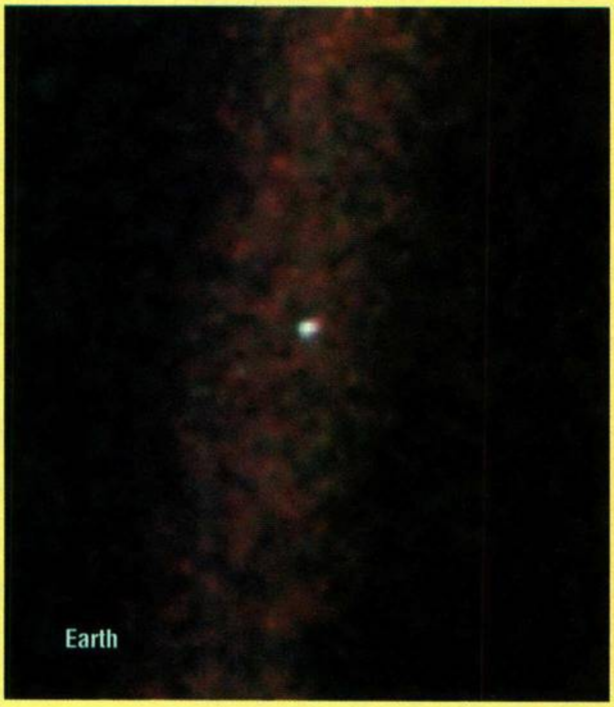
by John Williams



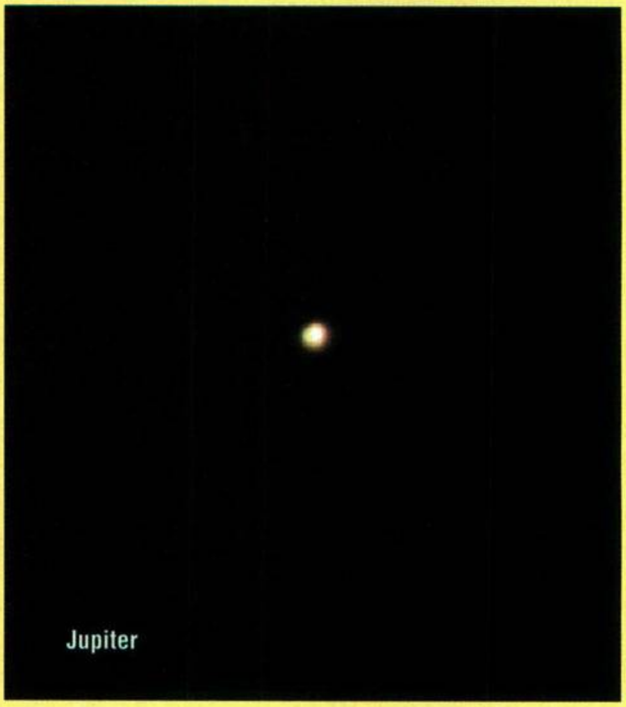
Venus



Sun, Venus, and Earth



Earth



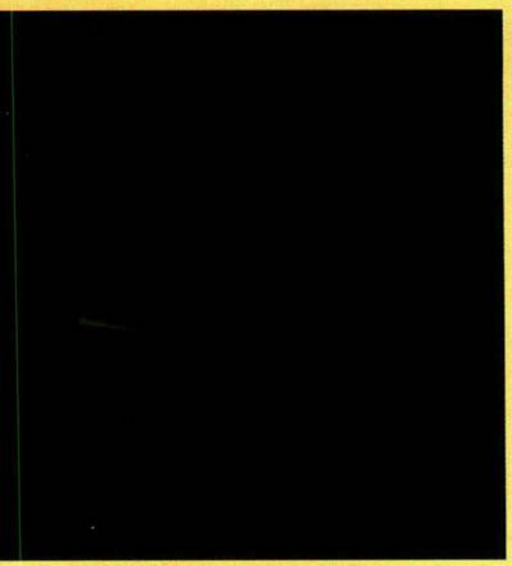
Jupiter

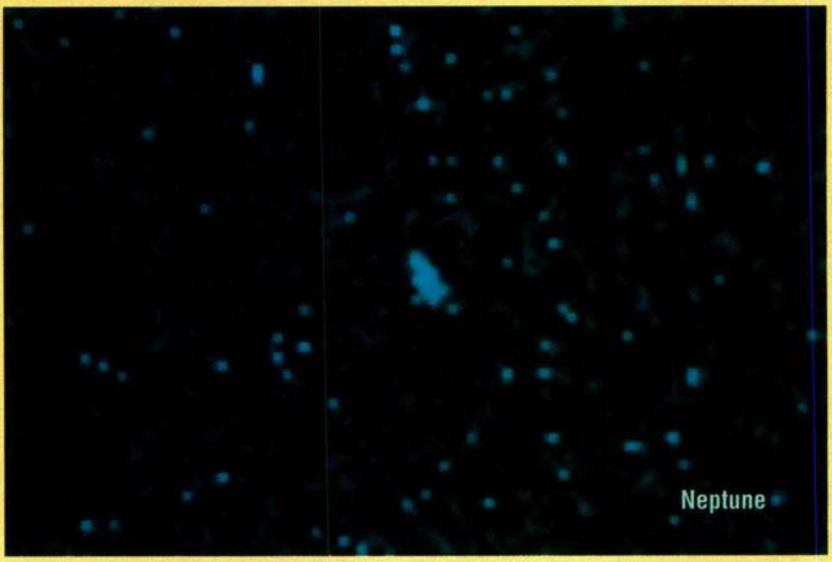
Alone some 3.7 billion miles from Earth, *Voyager 1*'s slewing motors came to life again in February after an almost 10-year hiatus. The mission this time was very different from the spacecraft's successful string of planetary flybys, however. This time *Voyager 1* turned its cameras back toward the Sun and planets and, for the first time in history, took a series of images showing the solar system from the outside — a family portrait of our planetary system.

"This is not just the first time, but perhaps the only time for decades, that we will be able to take a picture of the planets from outside the solar system," says *Voyager* project scientist Edward C. Stone of the California Institute of Technology.

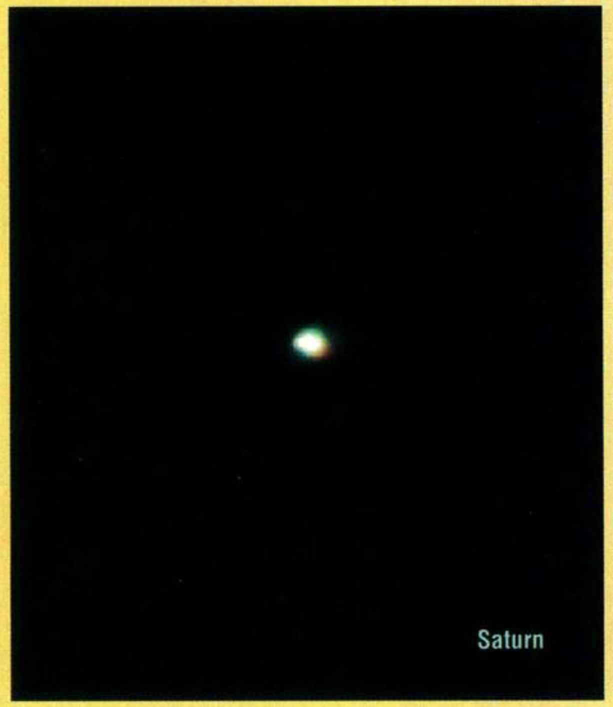
On February 13, nearly four billion miles out, all was relatively quiet as the spacecraft prepared for a four-hour photo shoot. *Voyager 1* turned its cameras toward the intensely bright point-like Sun (measuring a mere 40 arcseconds across) and then toward the specks of faint planets floating against the starry background of the constellation Eridanus the River. *Voyager* was 32° above the ecliptic plane and was nearly 1.5 times more distant than Pluto. Slowly and methodically, the spacecraft's wide-angle and narrow-angle cameras snapped sixty-four images, beginning with the dimmest of the targets, Neptune, and working Sunward. Although Mars, Mercury, and Pluto lay in the field of the composite photo, these planets remained elusive. Mars was made invisible by sunlight scattered in the camera's optics. Mercury was too close to the Sun to be seen. And Pluto was simply too distant and dim to be recorded.

Because NASA's Deep Space Network was scheduled to track several other spacecraft, the *Voyager* data were simply recorded on tape aboard the spacecraft and transmitted to Earth in late March. On June 6

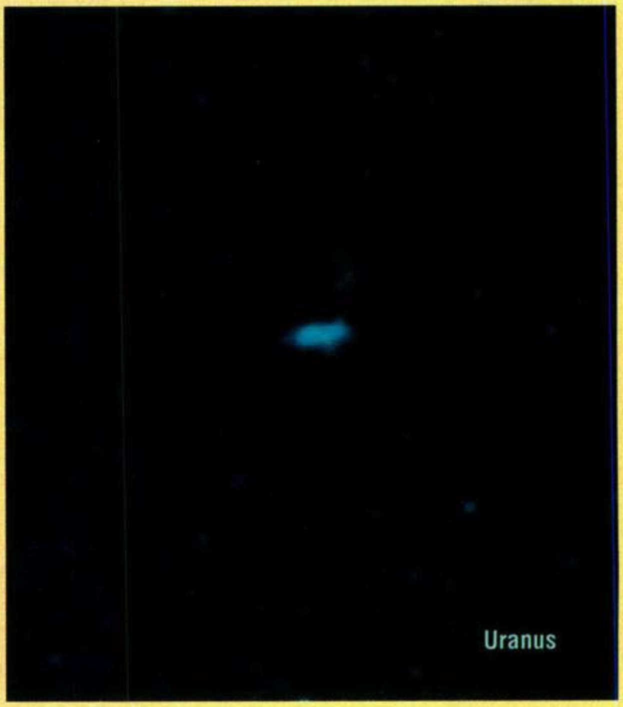




Neptune



Saturn



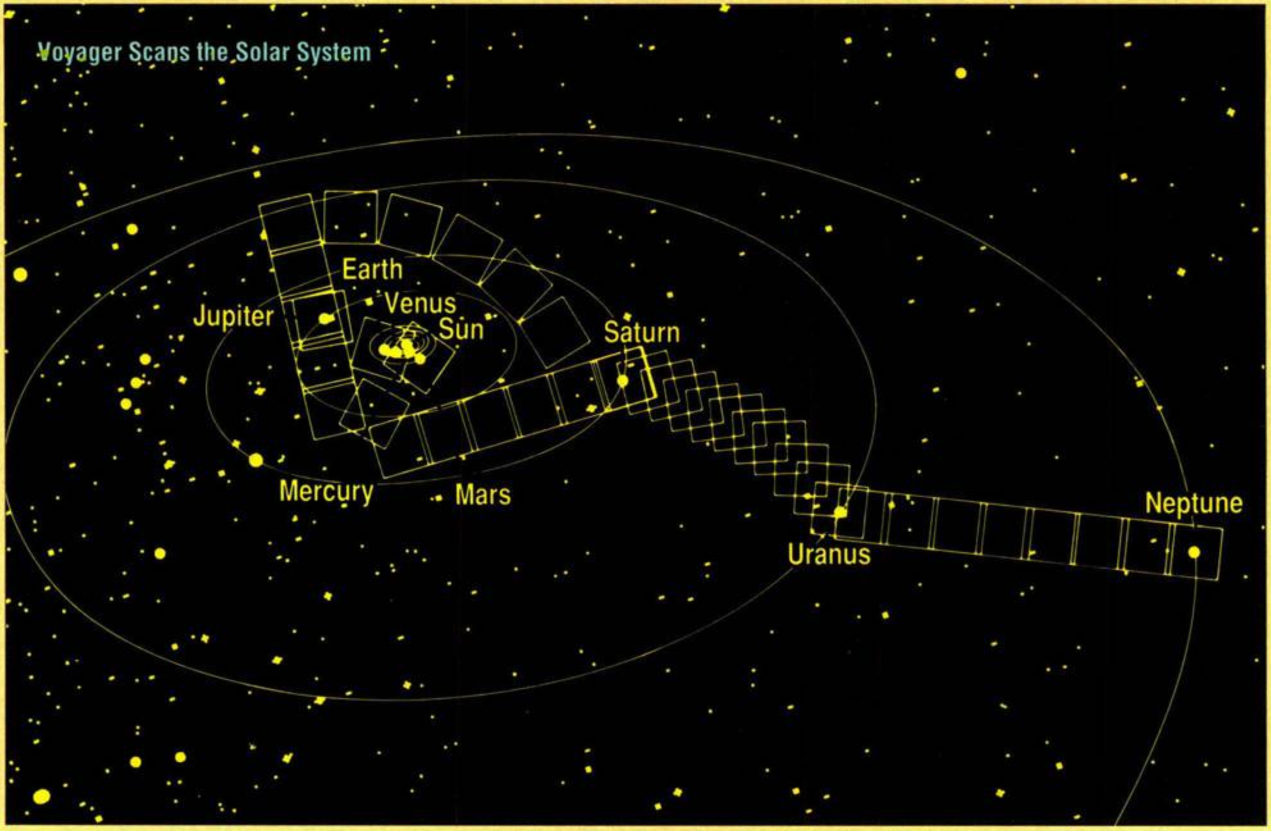
Uranus

PERSONALIZED PORTRAITS of the home star system were taken from outside the solar system for the first time by *Voyager 1*. The spacecraft's narrow-field camera recorded the images over a four-hour period on February 13. Venus is a tiny bluish blob only 1.3 pixels across, and the crescent Earth spans only 1.4 pixels. Jupiter and Saturn are clean disks, and Saturn's rings are visible as a five-pixel extension on one side of the planet. Because Uranus and Neptune required long exposure times to record, their bluish light appears smeared into linear blobs. NASA photos.

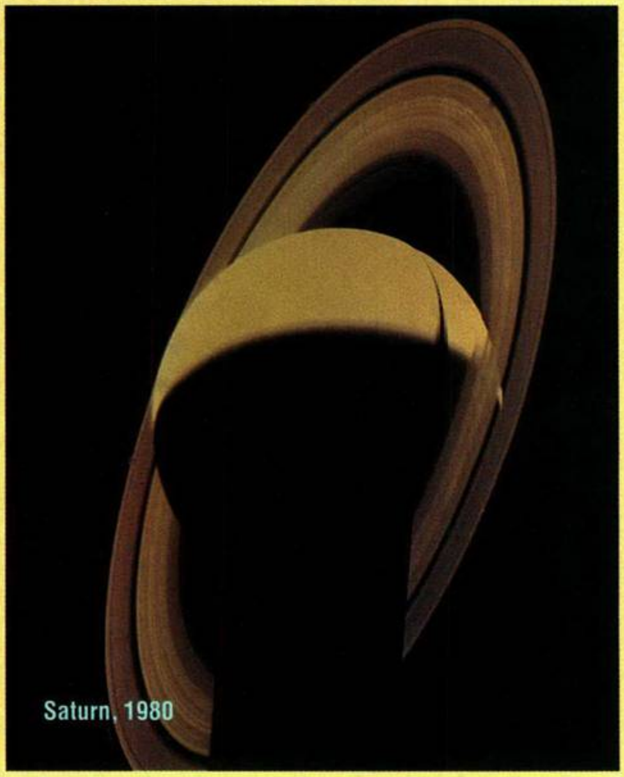
NASA released a collection of photos that included a composite image showing the Sun, Earth, and Venus, as well as individual pictures of Earth, Venus, Jupiter, Saturn, Uranus, and Neptune. Further mosaic images yet to be released may show more of the solar system in a single composite image.

"The biggest problem was identifying which blip was which planet," says Candy Hansen of the *Voyager* imaging team. "Jupiter and Saturn were easy, but the others were hard to find. Unfortunately, Mars couldn't be identified with any degree of confidence. The image of Earth is the most significant because it's the only place in the solar system that can support life. That's a mind-blowing concept when you see it photographed from outside."

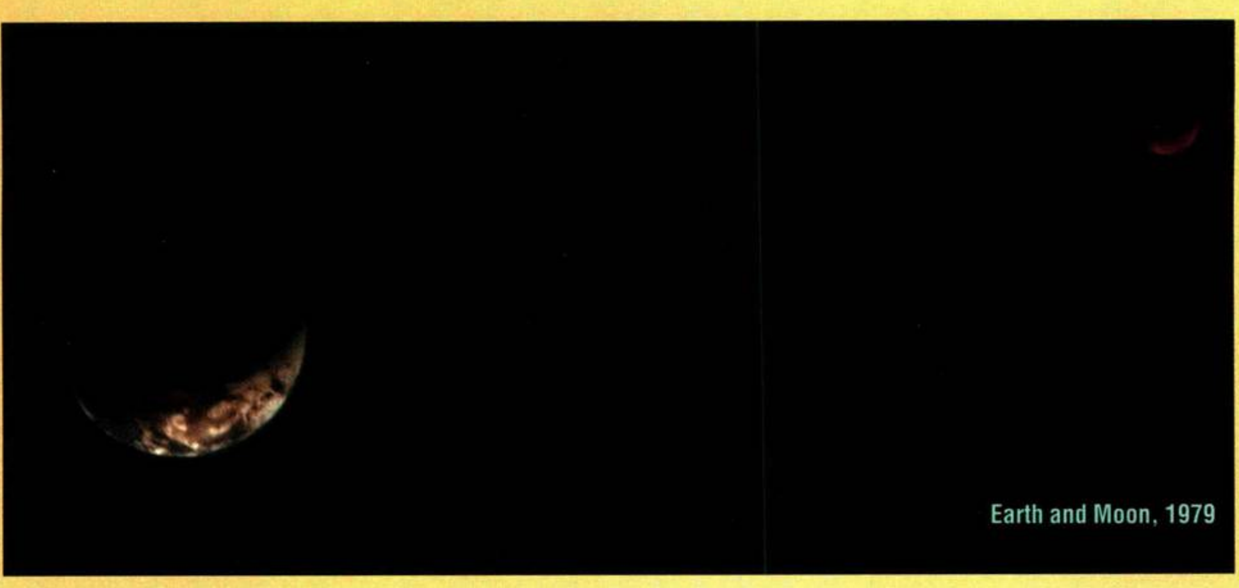
The color image showing the Sun, Earth, and Venus is a portion of a wide-angle image showing the Sun with narrow-angle images of Earth and Venus dropped into the correct spots. Because the Sun's great brightness might harm the cameras, scientists employed a dark methane-band absorption filter and a 1/200-second exposure, the shortest possible. The photo shows a greatly overexposed image of the Sun, tiny at the spacecraft's distance, but still over eight


Voyager Scans the Solar System
Earth
Venus
Jupiter
Sun
Saturn
Mercury
Mars
Neptune
Uranus

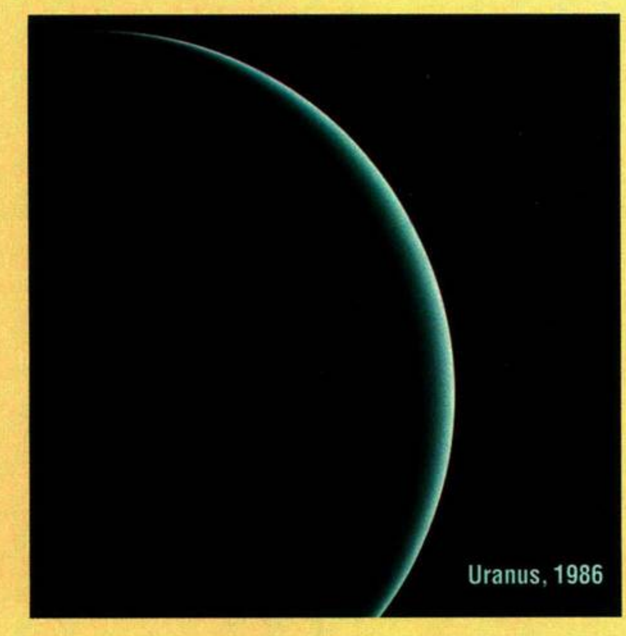
Jupiter, 1979


Saturn, 1980

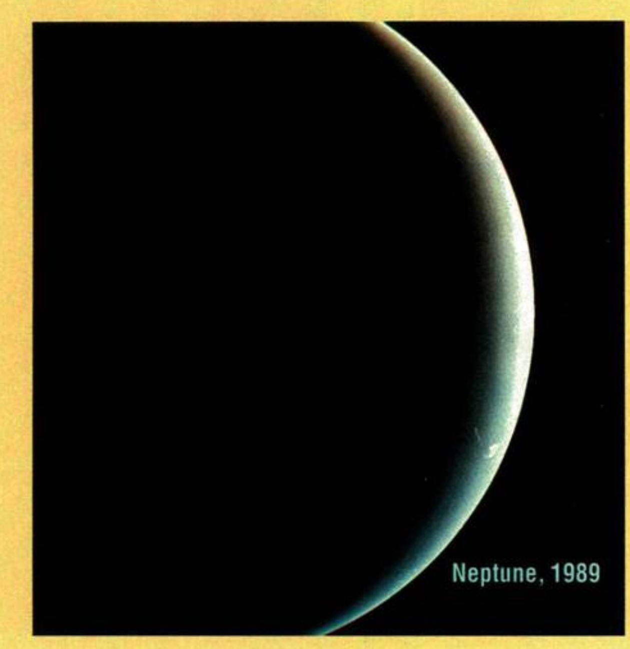
VOYAGER 1'S CAREER spanned thirteen years on a unique trek through the solar system. The final, historic operation occurred in February 1990 as the spacecraft panned its cameras from the dimmest target, Neptune, in toward the Sun, capturing Uranus, Saturn, Jupiter, Earth, and Venus along the way. Prior to the Sun's family portrait, *Voyager 1* carried out extensive reconnaissance of Jupiter and Saturn in 1979 and 1980 and photographed the Earth and Moon together shortly after its launch. *Voyager's* sister craft, *Voyager 2*, not only made scientific observations at Jupiter and Saturn but more recently encountered Uranus, in 1986, and last year flew past Neptune. NASA photos.



Earth and Moon, 1979



Uranus, 1986



Neptune, 1989

million times brighter than Sirius is in our night sky. (The Sun's magnitude from the spacecraft was –18.7, and this light all fell into 3.3 pixels in the wide-angle camera and 40 pixels in the narrow-angle camera.)

The "rays" around the Sun are a diffraction pattern caused by the calibration lamp mounted in front of the wide-angle camera. The insets were made with the narrow-angle camera and show Earth and Venus as dots surrounded by scattered rays of sunlight that streamed through the field. Image processing shows that *Voyager's* cameras faintly recorded the Moon as well as Earth, but it is invisible in these reproductions.

Individual color portraits made with the narrow-angle camera show the planets much better. The images were made using violet, blue, and green filters and were then combined into a single color photo. Jupiter and Saturn are resolved, but Uranus and Neptune are slightly smeared because of the spacecraft's motion during the15-second exposures required. Saturn's rings are visible as a five-pixel-long extension on one side of the planet. The crescent Earth appears to be centered in a band of light, actually a ray of sunlight scattered across the field by the camera's optics. Venus is centered and measures 1.3 pixels in diameter, slightly smaller than Earth's 1.4 pixels.

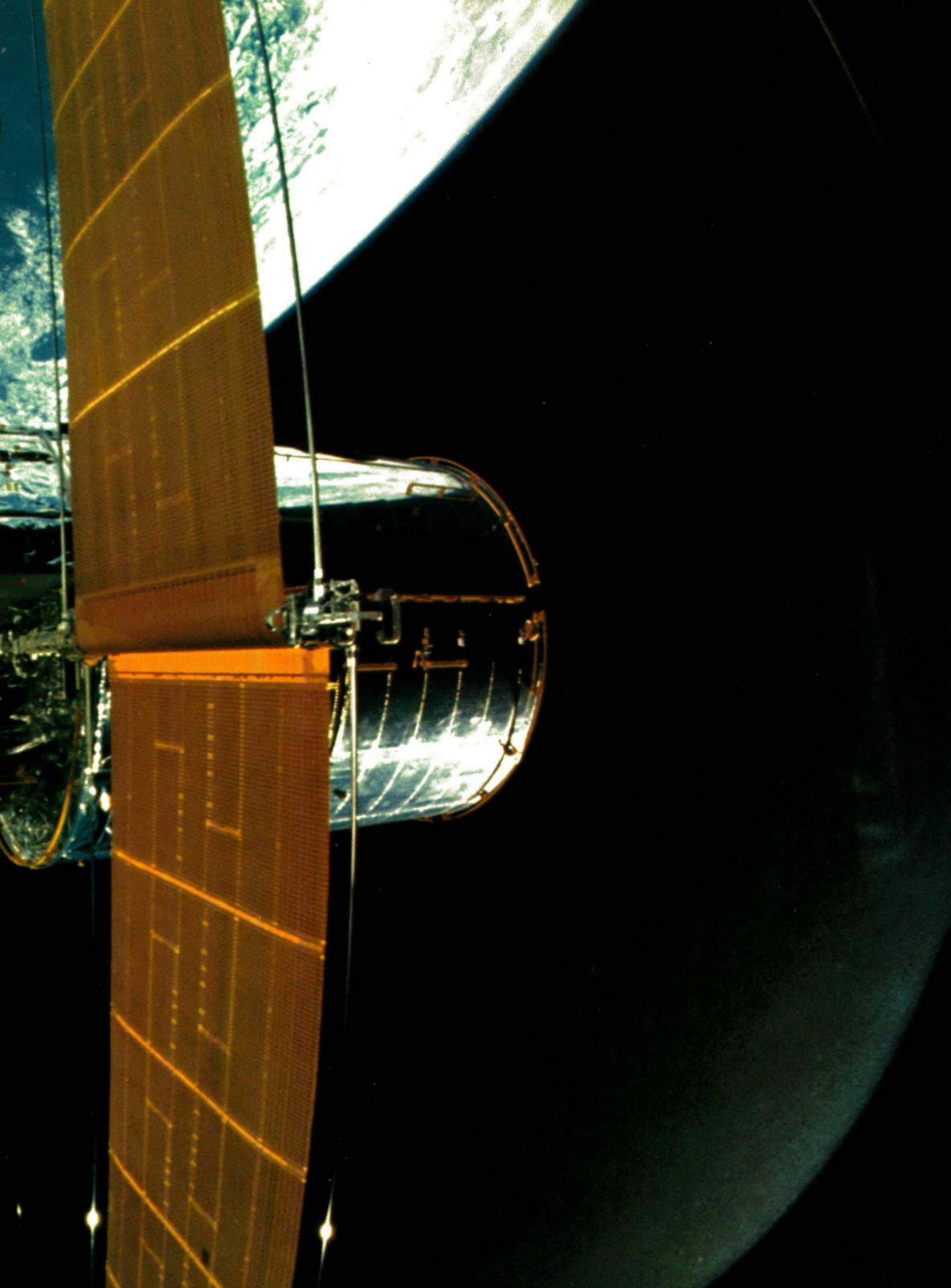
The family portrait is the last hurrah for *Voyager 1*. After its launch on September 5, 1977, the craft successfully completed flybys of Jupiter and Saturn in 1979 and 1980, respectively. *Voyager's* sister craft, *Voyager 2*, flew past Jupiter in 1979, Saturn in 1981, Uranus in 1986, and Neptune in 1989. Both are now racing toward the heliopause, the point where the solar wind slams into interstellar space. Scientists expect both craft will cross this boundary during the next ten to twenty years. As the *Voyager* craft head deeper into the darkness, scientists will also look for any variation in the spacecrafts' trajectories. Any deviance in these paths may reveal the presence of an unknown body in the solar system, the existence of which is suspected by some astronomers. That would be, in the words of one scientist, "one heck of a finale!" ☐

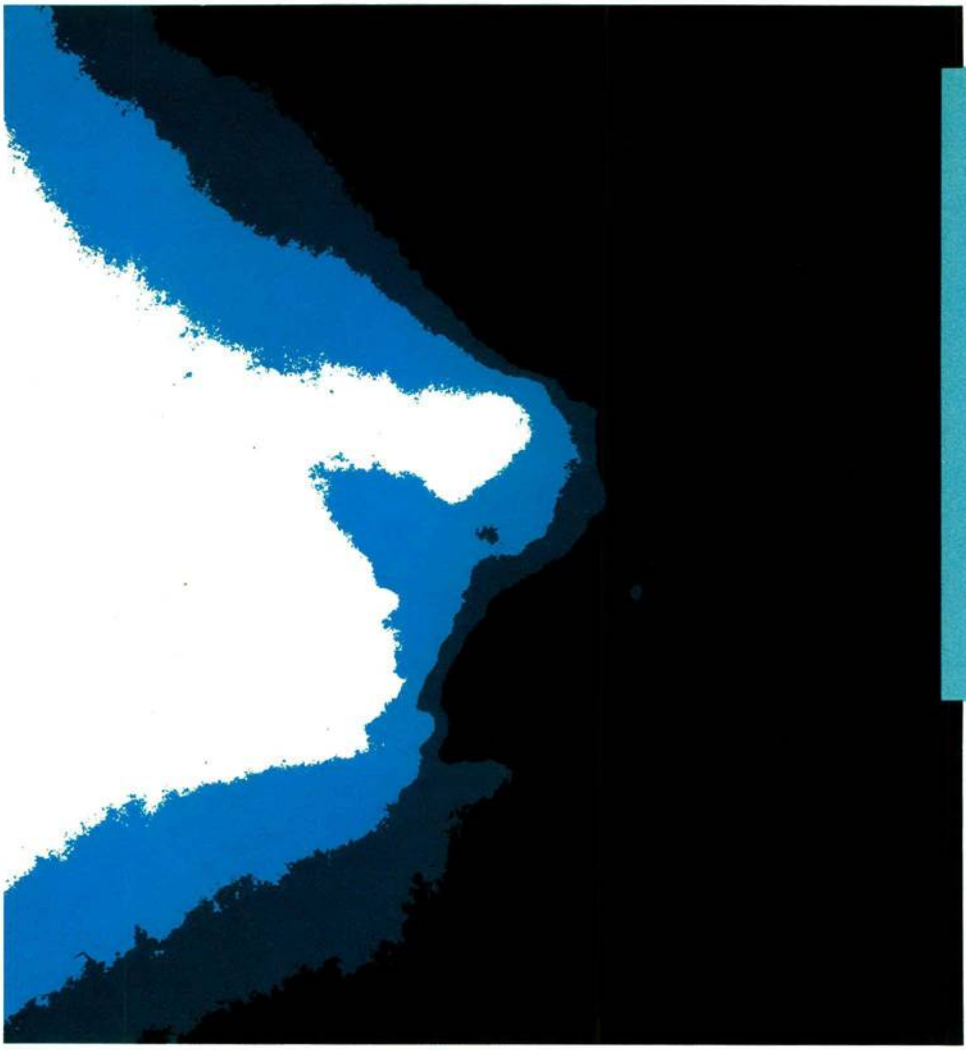
John Williams is a freelance science writer living in Jefferson City, Missouri.

Hubble's Brave New Universe

If you want an idea of how revolutionary the Hubble Space Telescope will be, take a look at what astronomers are planning to observe in the first year.

by Jeff Kanipe





With its sharp views of solar system objects, Hubble will let planetary astronomers answer fundamental questions about our nearest neighbors.

Behind all the promise of the *Hubble Space Telescope* lies an impressive scientific strategy. During its first year of operation, *Hubble* will attempt to carry out 467 observing projects. These run the gamut from planetary meteorology to black holes to the age of the universe itself. If only half of these observations are carried out in the first year, a dizzying number of astronomical questions will be answered. Here's a quick look at some of the more exciting projects that promise to change our view of the universe forever.

First and foremost, *Hubble* is a resolving machine. As it orbits almost 400 miles high, its strongest suit is the ability to see details obliterated by turbulence in Earth's atmosphere. By providing extremely sharp views, it will let planetary astronomers answer fundamental questions about our nearest neighbors.

Philip James of the University of Missouri plans to use *Hubble's* Wide Field/Planetary Camera to observe Mars. The WF/PC (pronounced "wiff-pick") provides the highest resolution of all of the space telescope's instruments; it could resolve a baseball at a distance of 200 miles. Over a three-year period, James will use the WF/PC's high resolution to map Martian surface features, look for seasonal and yearly variations in the brightness of these features, study the behavior of Martian clouds and dust storms, and measure changes in the polar caps.

Observers will also investigate comets and asteroids. James Westphal of Caltech will use the camera to look for satellites around asteroids as the asteroids occult bright stars. And Rudolf Albrecht, of the Space Telescope European Coordinating Facility, will use the Faint Object Camera for directly determining the physical properties of certain asteroids: diameters, surface features, rotation rates, and possible binary nature.

Comet rotation periods also interest Robert Bless of the University of Wisconsin. He will use the High Speed Photometer, capable of detecting small and rapid changes in brightness, to observe Comet Halley or other distant comet nuclei. Halley is a good choice, though, now that it lies far from the Sun and has become inactive. Bless thinks that Halley's Sun-raised "atmosphere" of sublimated ice and dust will have disappeared and its nucleus will be in clear view. He hopes to measure the light curve of the tumbling nucleus, thereby yielding its rotation period and settling a nagging question left over from the 1986 apparition. The work should also provide information about comet dynamics in general.

Mysterious Pluto will be scrutinized by Alan Stern of the University of Colorado, Marc Buie of the Space Telescope Science Institute, and Laurence Trafton of the University of Texas at Austin. They'll use the Faint Object Spectrograph, which records the chemical makeup of faint objects, to make the first direct analysis of Pluto's surface and the methane snowstorms of what Stern thinks may be a "collapsing" atmosphere. A decade ago, as Pluto was nearing the Sun in its eccentric orbit, its surface frosts sublimated into gas, forming an atmosphere. Now that Pluto is drawing away from the Sun's warmth, however, its atmosphere will be freezing out and falling to the surface.

The Stern team will also use the WF/PC to take photographs of Pluto. These images, combined with the spectrograph data, should reveal the composition of the light and dark features that ground-based observers have already detected. "The bright spots may prove to be fresh methane snow," says Stern. "The dark spots may be old methane snow discolored by long exposure to sunlight."

The "empty" space between the stars — the interstellar medium — is shocked by exploding suns, moves under the gravitational influence of the Galactic disk, and is enriched with heavier elements ejected by dying stars. Far from being cold and sterile, the interstellar medium is a fertile, dynamic environment where stars are born, and it is the graveyard to which they return when they die.

Astronomers want to study the structure, composition, and evolution of the interstellar medium, both locally and at great distances. *Hubble* will observe the hot gas in star-forming regions and the dynamics of supernova remnants and the remnants' interactions with the interstellar medium. It will also look for disks of dusty gas around newborn stars.

The local interstellar medium will be surveyed by a team of French astronomers using *Hubble's* High Resolution Spectrograph. They will map the structure of interstellar gas within about 25 light-years of the Sun by looking at its effects on light from more distant stars. "The aim of this study," claims principal investigator Rosine Lallement, "is to determine the characteristics of the 'parcel' of interstellar medium in which the Sun is embedded."

The local cloud is also a target for Sara Heap of Goddard Space Flight Center and her colleagues, who propose to search for evidence of shocked material on the outskirts of the local cloud using the High Resolution Spectrograph. They think they will find shocked gas if the nearby interstellar medium experienced a supernova explosion within the past few million years.

The Crab Nebula supernova remnant and its turbulent environment is a subject of imaging and spectroscopy by a team of American astronomers lead by Kris Davidson of the University of Minnesota. They plan to use the WF/PC, the Faint Object Spectrograph, and the Faint Object Camera to study this nebula where a supernova exploded nearly a thousand years ago. The Crab is a young supernova remnant in which condensations of ejected material can be resolved. Ultraviolet observations plus direct imagery and spectroscopy will let Davidson's team profile the Crab's dynamics, mass, and chemical composition.

One of the more ambitious supernova-related projects is a study of bright supernova remnants, including SN 1987A, over an extended period using *Hubble's* cameras and spectrographs. According to the project's principal investigator, Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics, the observations will address several key problems in supernova research, including the chemical evolution of supernova remnants and how they affect the structure of the interstellar medium. As Kirshner says, "Because supernovae touch on so many fields of astronomy, the results of this study will affect a broad range of areas from stellar interiors to cosmology."

Stellar astronomy sprawls across a wide range of research fields: stellar populations, binary and variable stars, pulsars, and star-birth and star-death. It also includes extrasolar planet research, since planets are a byproduct of star formation and hunting for them involves observing stars and the environment

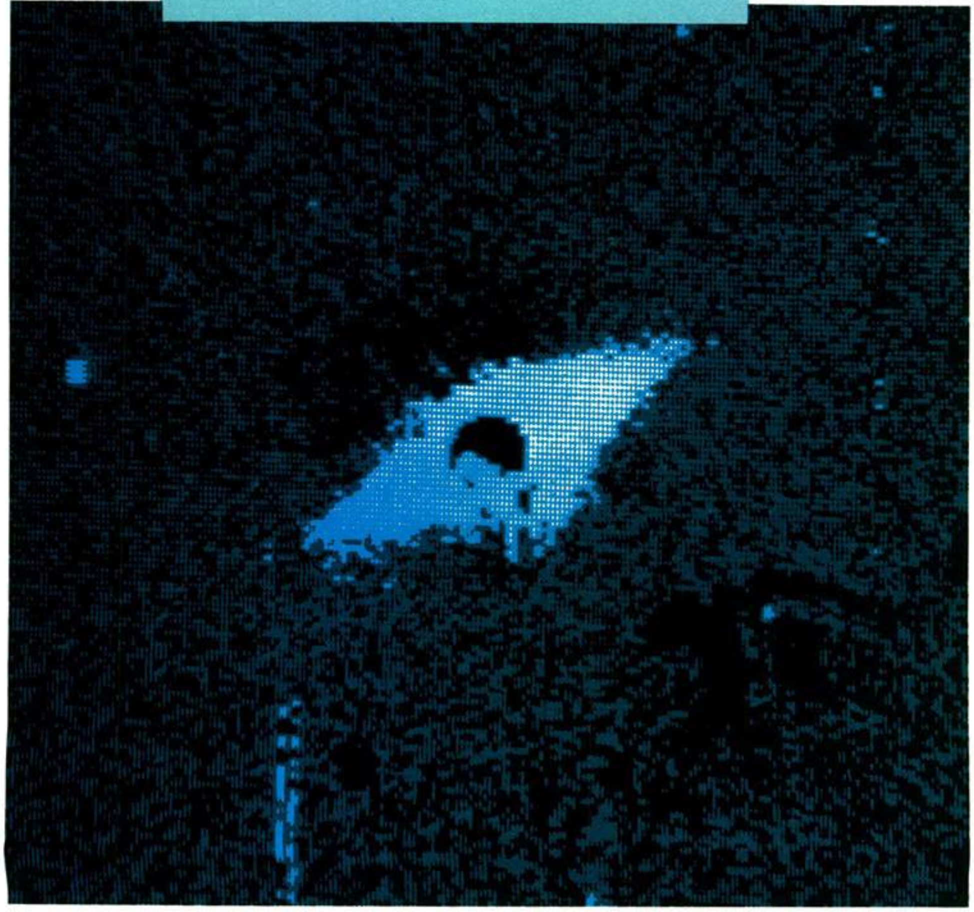
The interstellar medium is a fertile, dynamic environment where stars are born, and it is the graveyard to which they return when they die.

around stars.

Jay Bookbinder of the Center for Astrophysics and his colleagues hope to study millisecond pulsars, a class of neutron stars that rotate hundreds of times per second. These objects result when neutron stars "spin up," probably by pulling material from a very close companion star.

Bookbinder's group wants to observe PSR 1957+20, a unique 1.6 millisecond pulsar that is eclipsed by its companion every 9 hours for about 50 minutes. Observations made two years ago indicate that the companion star is "evaporating" under a ceaseless blast of plasma jetting from the magnetic poles of the pulsar (see AstroNews, February 1989). Using the Faint Object Spectrograph and the WF/PC, the astronomers hope to pin down the companion star's magnitude and determine its temperature, density, and structure, as well as the chemical makeup of the material drawn from the companion star.

Stellar research encompasses everything from stellar populations to binary and variable stars to the exciting possibility of extrasolar planets.



Not all binary star systems are so exotic. Nevertheless, studies of the gravitational tug-of-war between two close stars are important because they provide the only direct means of measuring stellar masses. Some binary stars provide a unique dynamical laboratory, especially those stars that orbit so close that they exchange matter.

One such class of binary star is the cataclysmic variable. In these systems, one member is a white dwarf while the other is usually a main sequence star or a red giant. Mass from the donor star collects in an accretion disk around the white dwarf. At irregular intervals, material dumped onto the disk around the white dwarf will ignite in a thermonuclear explosion, causing the star to brighten unpredictably.

Astronomer Keith Horne of the Space Telescope Science Institute and his group will use the Faint Object Spectrograph to take ultraviolet observations of eight cataclysmic variables. Their goal is to determine the masses, sizes, and temperatures of the component stars in these systems. They will then try to ascertain the rate at which mass is being transferred to the white dwarf and will also map out the little-understood region lying between the inner accretion disk and the white dwarf itself. Their results will test theories on both the structure of stellar accretion disks and the evolution of close binaries.

A natural outgrowth of stellar astrophysics is the search for planets around stars. Astronomers believe the Sun's planets condensed out of a circumstellar disk of dust particles. Data gathered from *IRAS* (the *Infrared Astronomical Satellite*), ground-based radio telescopes, and very delicate measurements of Doppler shifts indicate that a number of stars are girdled by broad, thin protoplanetary disks. Some stars are thought to have cool, Jupiter-size companions.

William Jefferys of the University of Texas will look for Jupiter-like planetary companions around six to ten low-mass stars. Using the telescope's fine-guidance sensors, Jefferys will search for minute changes in the positions of these stars, caused by the gravitational tugs from massive planets. The sensors provide precise measurements of a star's location, letting astronomers chart its movement over several years.

Understanding the nature of galaxies is critical to understanding the structure and evolution of the universe as a whole. *Hubble* will be used to resolve hitherto-unseen details in galaxies.

Stuart Vogel of the University of Maryland and his colleagues want to understand how stars grow old in galaxies. They plan to use the WF/PC to image star clusters in the Whirlpool Galaxy M51, which lies in Canes Venatici. Astronomers think that spiral arms in such galaxies occur when dense bands of matter, called density waves, sweep through the disk of a galaxy, triggering stars to form. The particulars of this process are unknown, however, and the hypothesis may even be completely wrong.

Vogel will carefully observe the brightness of star clusters lying "downstream" from density waves to see if the clusters brighten with age. If so, this will let Vogel's team clock the early stages of star formation. These data can then be used to pin down when giant molecular clouds — the stellar breeding grounds — first assemble in the wake of a density wave's passage. Vogel's team will also determine whether M51's molecular dust clouds produce stars on their own or are merely inert objects compressed into star-formation by the moving density wave.

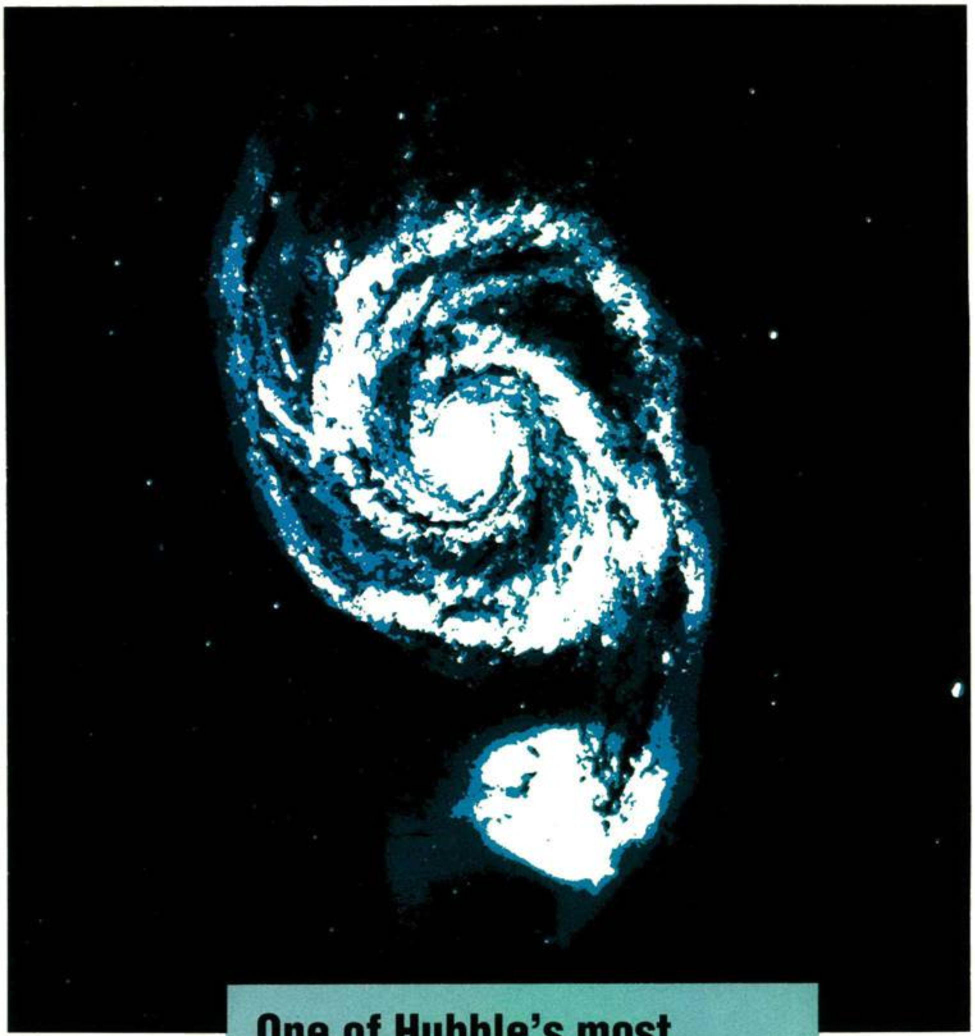
Nor are spirals the only galaxies to be studied. Sandra Faber of the University of California, Santa Cruz, is the director of a project that will employ both the Faint Object Spectrograph and the WF/PC to look into the cores of 51 elliptical galaxies. Faber's group will search for massive black holes by measuring the velocity of gas in the immediate vicinity of the galaxies' cores. Gas that is moving rapidly points to the gravitational influence of a very massive but small central object.

Faber's group will also compare the structures of the cores of low-luminosity ellipticals, giant ellipticals, and dwarf ellipticals to see how these differ with respect to the overall structure of the galaxy. This long-term project should help astronomers understand more about the nature and evolution of elliptical galaxies, which make up about 70 percent of all galaxies known.

One of the most eagerly anticipated tasks planned for *Hubble* is the calibration of the extragalactic distance scale. The research will be conducted by a large number of astronomers led by Jeremy Mould of Caltech. It aims to establish within a factor of about 10 percent how quickly the universe is expanding. The observations should in turn yield an age for the universe that is more reliable than the current estimate of 10 to 20 billion years. "The rate of expansion of the universe is one of those numbers right at the heart of astronomy," says co-investigator Garth Illingworth of the University of California, Santa Cruz, "but it's so very uncertain."

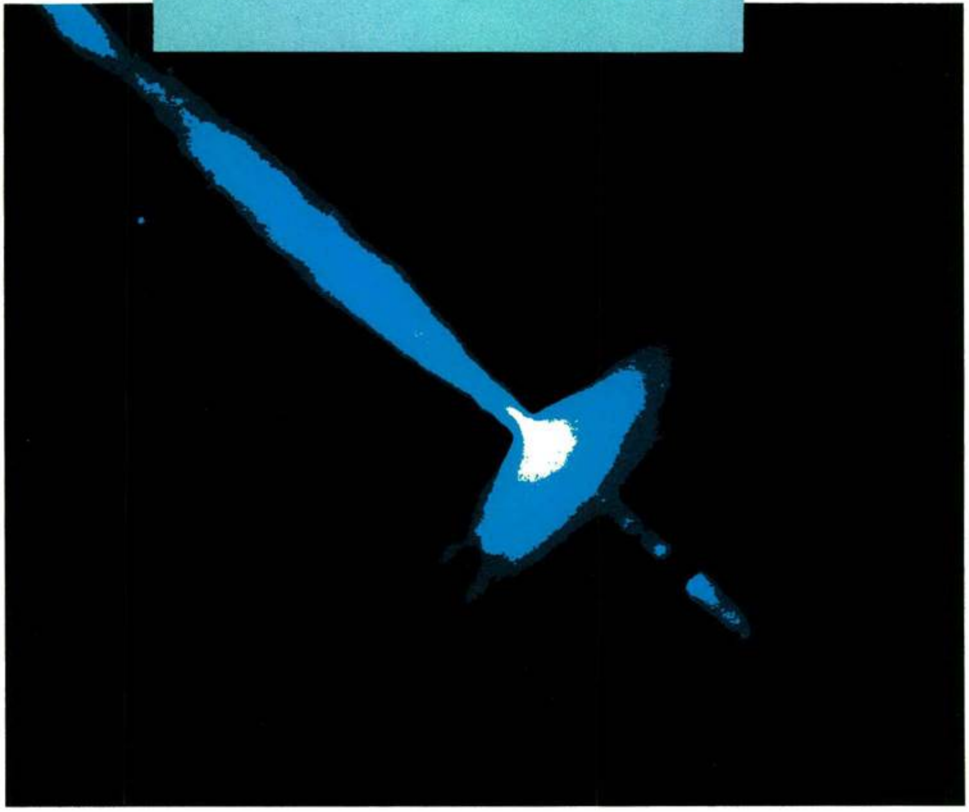
The team's primary targets are Cepheid variable stars in nearby galaxies. Cepheids are bright, massive stars that pulsate with periods related to their true brightnesses. With ground-based telescopes, Cepheids are bright enough to let astronomers measure the distances to only the nearest galaxies. But the motions of these galaxies in the expanding universe are perturbed to an unknown extent by the gravity of the Local Group of galaxies. Mould's group plans to observe Cepheids in more distant galaxies, perhaps even out to the Virgo Cluster, where they hope the rate of expansion is more uniform and less disturbed than it is locally.

The project, to be combined with other observing tasks, is expected to take years to complete. But if any one endeavor embodies the real meaning of the *Hubble Space Telescope*, it is this one. "In a sense," says Illingworth, "we'll be finishing off something that Edwin Hubble himself started 70 years ago."



One of Hubble's most eagerly anticipated tasks is calibrating the extragalactic distance scale — the very work that Edwin Hubble pioneered 70 years ago.

The cores of active galaxies and quasars are so energetic that they may embody new physical processes as yet unknown on Earth.



Extremes always fascinate, and active galaxies and quasars are about as extreme as you can get. The cores of active galaxies and quasars are so energetic they may employ new kinds of processes, as yet unknown and perhaps impossible to observe on Earth.

One of the prime active galaxies to be studied by *Hubble* is the giant elliptical M87 in Virgo. Holland Ford of the Space Telescope Science Institute will employ the WF/PC and the Faint Object Spectrograph to examine the bright jet erupting from the galaxy's core. The jet consists of plasma shot out from the vicinity of what many astronomers believe is a massive black hole at the heart of the galaxy. Ford proposes to measure the jet's velocity and establish the physical conditions and chemical composition of the gas in the jet. *Hubble*'s finely detailed resolution, ideally matched to the size of the knots seen in radio images of the jet, will likely reveal new structures that could help astronomers understand the dynamics of the suspected black hole's surroundings.

Astronomers have come to think that active galaxies and quasars are evolutionarily linked. But quasars are hundreds of times more luminous than the most active galaxies and can be seen at extremely remote distances. What powers these bright beacons? The only possibility, say many astronomers, is the accretion of matter onto a black hole with a mass of some 10 billion Suns. A team of astronomers led by Beverley Wills of the University of Texas will try to confirm this theory using the Faint Object Spectrograph. They propose to probe the inner few light-years of a sample of quasars and look for "spikes" of emission characteristic of massive accretion disks. They will also try to determine the structure of the core region of the quasars.

Because quasars are so bright and distant, they are perfect lighthouses for probing space between Earth and the quasars. Astronomers John Stocke and Michael Shull of the University of Colorado will use quasars to "backlight" gas clouds lying in cosmic voids, vast spherical regions that are apparently devoid of galaxies. Intervening matter lying between the quasars and Earth will absorb quasar light, leaving dark, telltale absorption lines in the quasars' spectra. Stocke exults, "It's like floodlighting a forest to detect trees by their shadows."

The astronomers will use *Hubble*'s Faint Object Spectrograph to look for absorption lines from ionized carbon, silicon, nitrogen, magnesium, and iron. Finding them would mean that the voids contain galaxies that cannot be seen because they either contain too few stars or are spread over a very large volume of space.

What if these subluminous galaxies are not found? Stocke says it's possible that the dark matter in the voids consists of primordial hydrogen clouds that just never formed into stars and galaxies. They would, in effect, be vast parcels of inert gas left over from the Big Bang but spanning millions of light-years. In any case, the findings should provide important clues to the formation of voids and how they relate to the overall large-scale structure of the universe.

As it soared into orbit, *Hubble* carried with it the hopes, dreams, and aspirations of probably every astronomer alive — for it is hard to imagine any corner of astronomical research that won't be affected by the robot observatory's extraordinary reach. The proposals outlined here are only a few percent of the first round of projects planned. Even by themselves, the results of these projects will change the course of astronomy. And yet — how much more revolutionary will a year's worth of observations be? Or two years?

It is more staggering still to realize that astronomers will be using *Hubble*'s sensitive instruments and high resolution for the next *fifteen years.* How will the universe look to us then? How will our changed views of it change *us*? ☐

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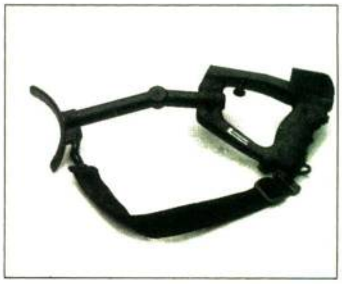

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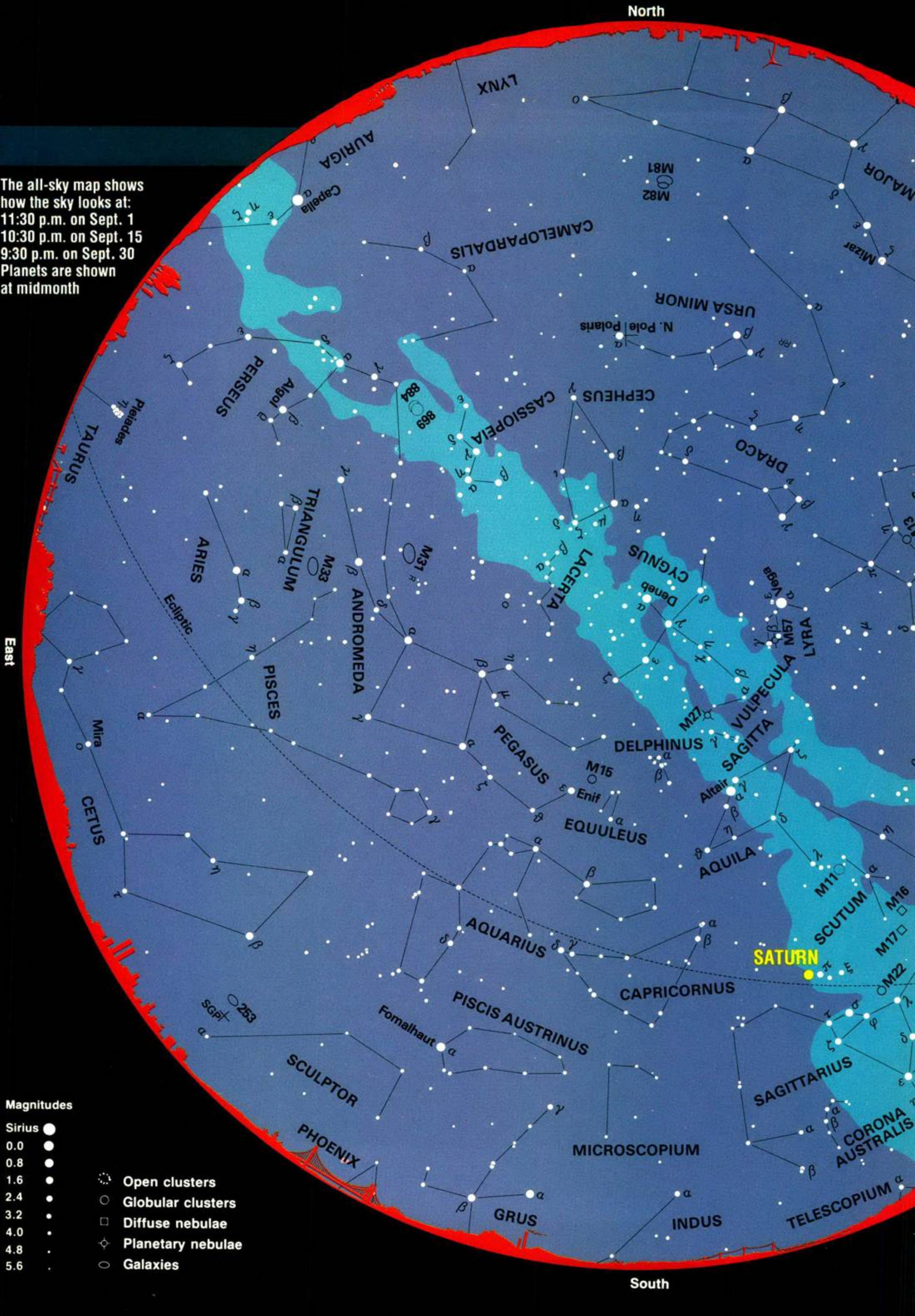
11:30 p.m. on Sept. 1
10:30 p.m. on Sept. 15
9:30 p.m. on Sept. 30
Planets are shown at midmonth


North
South
East
LYNX
AURIGA
Capella
M81
M82
CAMELOPARDALIS
MAJOR
Mizar
URSA MINOR
N. Pole
Polaris
PERSEUS
Algol
Pleiades
TAURUS
884
869
CASSIOPEIA
CEPHEUS
DRACO
TRIANGULUM
M33
M31
ARIES
ANDROMEDA
LACERTA
CYGNUS
Deneb
Vega
M57
LYRA
Ecliptic
PISCES
Mira
PEGASUS
VULPECULA
M27
DELPHINUS
SAGITTA
M15
Enif
Altair
EQUULEUS
AQUILA
CETUS
M11
SCUTUM
M16
M17
AQUARIUS
CAPRICORNUS
SATURN
M22
SGP
253
PISCIS AUSTRINUS
Fomalhaut
SCULPTOR
SAGITTARIUS
PHOENIX
MICROSCOPIUM
CORONA AUSTRALIS
GRUS
INDUS
TELESCOPIUM
Magnitudes
Sirius
0.0
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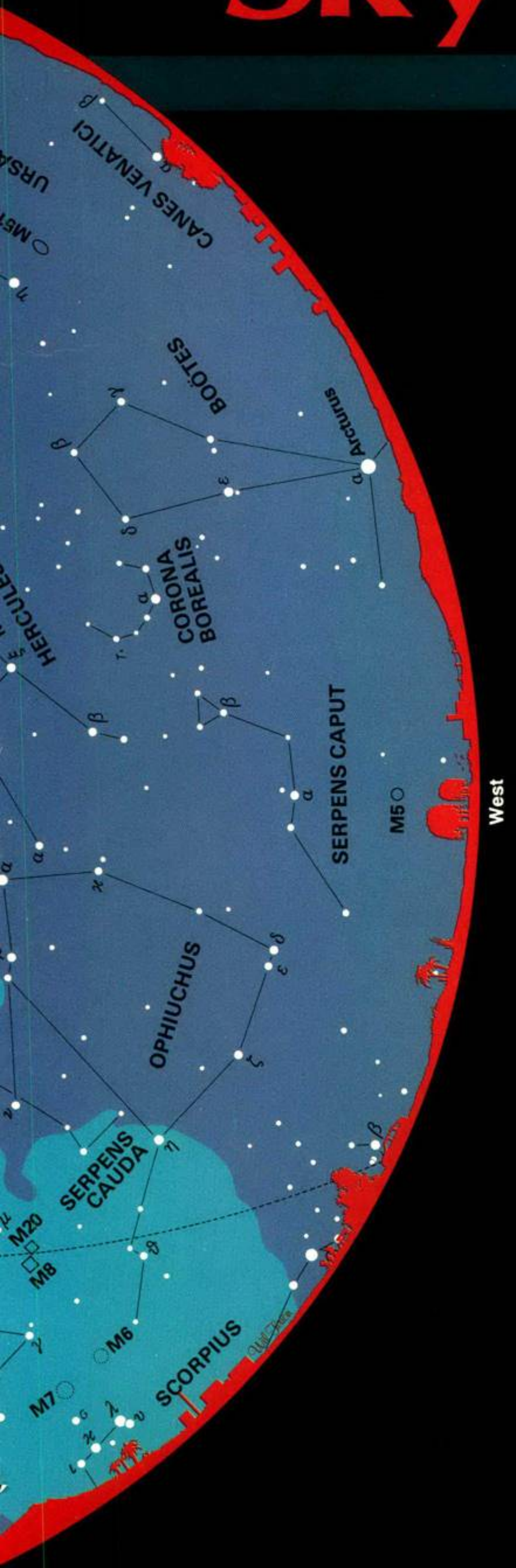
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

September 1990



LOOK FOR COMET LEVY

The second naked-eye comet of 1990 graces the evening sky during August and September. Comet Levy is expected to glow at about 4th magnitude and will be easy to spot from a dark-sky site during the two-week period around New Moon on August 20. By late September the comet fades slightly and moves much farther south, which makes it difficult to see from the Northern Hemisphere.

MARS BRIGHT IN THE EVENING

The bright, orange-red "star" rising in the east before midnight is none other than the planet Mars. At magnitude –0.6, the Red Planet is now the brightest object in the evening sky except for the Moon, and it is destined to brighten further before its opposition in late November.

A GOOD MONTH FOR MERCURY

Although many people believe Mercury is hard to spot, it is actually quite easy if you know when and where to look. In late September the innermost planet has an excellent apparition in the morning sky and can be found 10° above the eastern horizon thirty minutes before sunrise.

Calendar of Events

4 Full Moon is at 9:46 p.m. EDT

6 Venus passes 0.8° north of Regulus, 5 p.m. EDT

7 Mercury is in inferior conjunction

9 The Moon is at perigee (228,901 miles from Earth), 7:14 a.m. EDT

10 The Pleiades cluster is occulted by the Moon, 8 a.m. EDT

11 Last Quarter Moon is at 4:53 p.m. EDT

12 Comet Honda-Mrkos-Pajdusakova is at perihelion

14 Mercury passes 3° south of Venus, 11 a.m. EDT

15 The Moon passes 0.3° south of Jupiter, 2 a.m. EDT

17 The Moon passes 2° south of Mercury, 4 p.m. EDT

18 New Moon is at 8:46 p.m. EDT

22 Saturn is stationary

23 Autumnal equinox is at 2:55 a.m. EDT

24 Mercury is at greatest western elongation (18°)
The Moon is at apogee (251,534 miles from Earth), 6:15 p.m. EDT
The Moon passes 0.4° north of Antares, 9 p.m. EDT

25 Mars passes 4° north of Aldebaran, 3 a.m. EDT

26 First Quarter Moon is at 10:06 p.m. EDT

27 Isis is at opposition

28 The Moon passes 1.5° south of Saturn, 4 a.m. EDT

Eye on the Sky by *Deborah Byrd*

THE RED PLANET SHINES BRIGHTLY

This month, for the first time in two years, Mars is a ruddy beacon in our late evening sky. And although the planet is conspicuously bright now, it will brighten significantly by the time it reaches opposition on November 27, when Earth passes between Mars and the Sun.

The last time Mars was this bright was in 1988, when it had its best apparition since the 1950s. Mars was spectacular then because it reached perihelion, its closest point to the Sun, only a month and a half before opposition. That combination of circumstances brought the planet particularly close to us, within about 37 million miles.

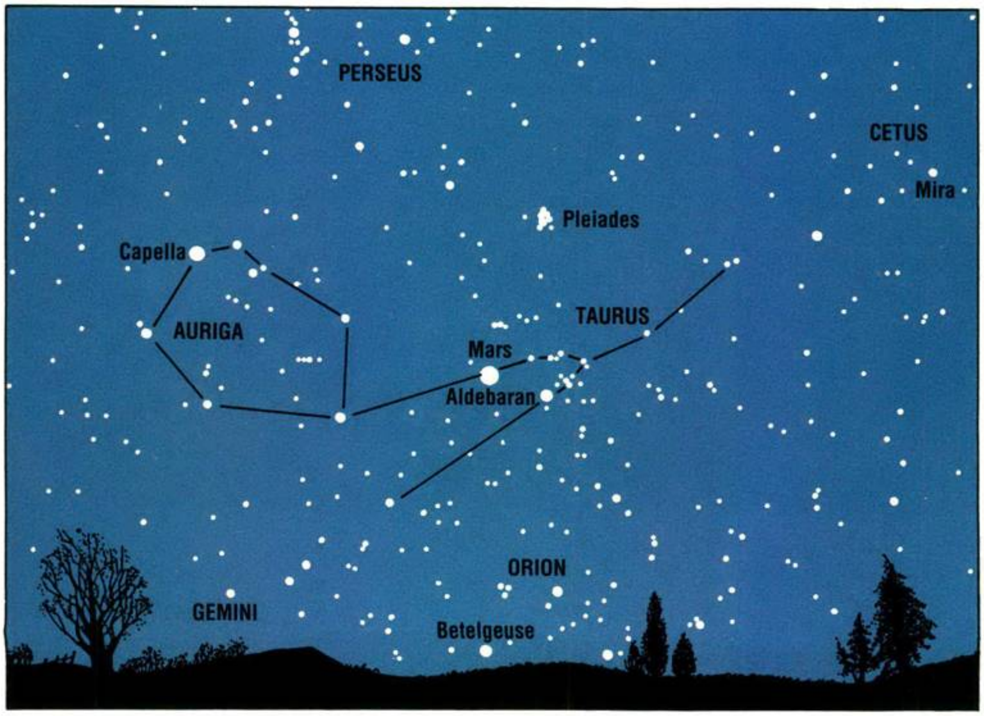
This year, Mars was at perihelion in June, some five months before it reaches opposition. Thus our two worlds will be farther apart at opposition, about 48 million miles, than in 1988. Although the planet won't be as close or as bright as it was two years ago, it will outshine every star and rival the second-brightest planet, Jupiter. What's more, Mars is better placed for observing this year than in 1988 because it is some 25° higher in the sky when it crosses the meridian (the line between due north and due south). Don't pass up the opportunity to view the Red Planet this month and through the end of the year; it won't be as prominent again until after the turn of the century.

A NAKED-EYE COMET FOR LATE SUMMER

Arizona comet hunter David Levy discovered his sixth comet in late May, and it should be bright enough to see with the naked eye in the evening sky during August and early September. Predicting how bright a comet will get is always a tricky business (remember Comet Austin?), but there is a good chance Comet Levy will become moderately bright.

After spending the first half of August in the constellation Pegasus, Comet Levy moves rapidly through Aquila and by September 1 resides in Sagittarius. From there it heads into Scorpius and ends the month in Lupus. Although the comet is expected to glow about 4th magnitude during this period, your best chance to see it comes in the latter part of August when the Moon is gone from the evening sky. As with any faint, fuzzy object, your chances of seeing the comet are best if you observe from under a dark sky. (See "Comets Encke and Levy: Something Old and Something New" on page 66 for more details on observing Comet Levy and the telescopic comet, Comet Encke.)

MARS SHINES BRILLIANTLY in the east around midnight in late September. This is just a hint at what lies ahead, however, because the Red Planet grows brighter and rises earlier as fall progresses.

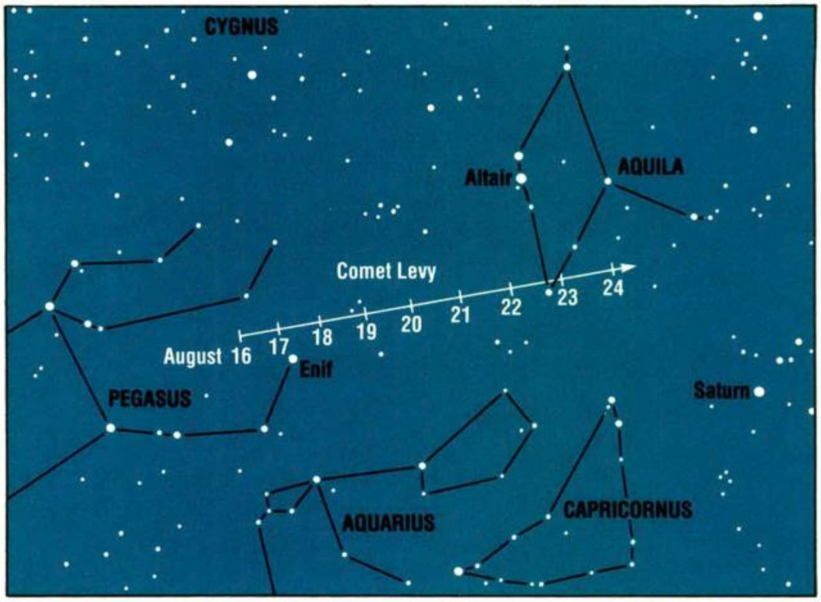


MERCURY IN THE MORNING

The most elusive planet, Mercury, is less elusive than usual this month. The innermost planet has its best morning apparition of the year in the second half of September and is visible low in the east before dawn. Mercury is at greatest elongation, when it is farthest from the Sun on the dome of our sky, on September 23/24.

The planet becomes visible a few days before then, however.

You can start looking for it about 45 minutes before the Sun rises; half an hour before sunrise Mercury lies due east and is about 10° above the horizon. At greatest elongation it shines at magnitude –0.4, significantly brighter than any nearby star.



DON'T MISS COMET LEVY this August and September as it reaches naked-eye visibility. The comet should be brightest in mid to late August when it appears high in the southeast after evening twilight ends.

SEPTEMBER'S PLANETS

Saturn is the first planet to appear as the sky grows dark after sunset. It is at its highest point in the south as twilight ends, and it sets not long after midnight.

The ringed planet is slightly fainter now, at magnitude 0.4, than it was at opposition in July. Another sign that Saturn's current apparition is winding down comes on September 22/23, when the planet resumes eastward motion. The planet will continue to move eastward, and grow fainter, in the coming months.

The next planet to appear is Mars, which rises in late evening and is high in the southeast before dawn. Mars is hard to miss this month it's a strikingly bright, orange-red object in the east during the late evening hours. And it becomes easier to see as September progresses, rising earlier and brightening by half a magnitude, from magnitude –0.4 to magnitude –0.9, during the course of the month.

Over the past several months Mars has whizzed eastward against the stellar backdrop, passing through many constellations in the process. In September, however, the Red Planet slows markedly, and it will remain among the stars of Taurus through the end of the year.

That places Mars near two famous star clusters, the tiny dipper-shaped Pleiades and the V-shaped Hyades. During September Mars slides between the two clusters, and it will do so again after beginning retrograde, or westward, motion next month. Mars also passes 4° north of Aldebaran, Taurus' brightest star, on September 24/25. Mars is easily the brighter object at magnitude –0.8, while the orange-tinged Aldebaran shines at magnitude 0.9.

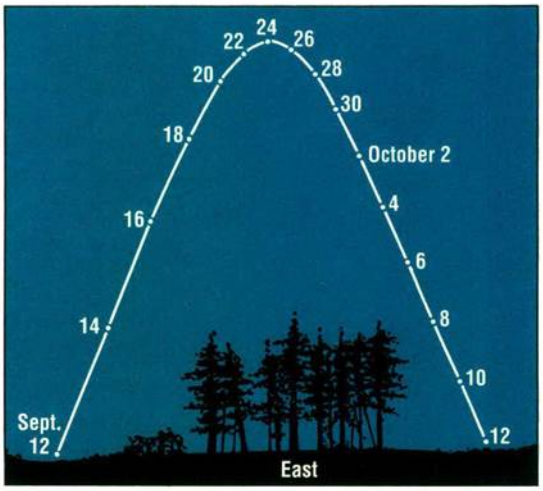
Jupiter has now replaced Venus as the glittering "morning star." Though not as bright as Venus, Jupiter is nevertheless brilliant at magnitude –1.9. The planet is approximately 20° high in the east about an hour before sunrise on September 1. It is midway up in the east before dawn by month's end.

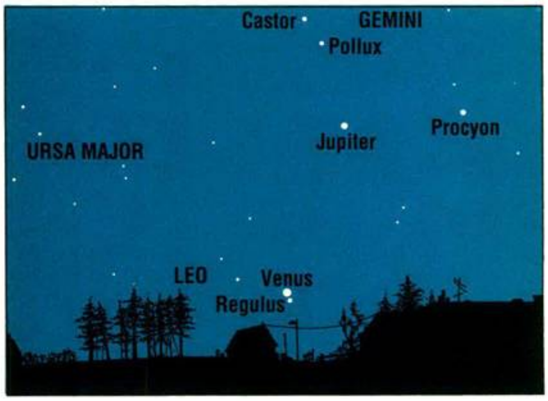
Jupiter lies in the inconspicuous constellation Cancer the Crab this month. Although none of the constellation's stars shines brighter than magnitude 3.5, Cancer does contain a grand binocular target, the Beehive star cluster, which is also known as Praesepe. Jupiter lies less than 2° south of the Beehive at the end of September.

Venus is so low in the predawn sky in September that you'll have to look carefully to see it. To catch a glimpse of the brightest planet, scan about 5° above the eastern horizon forty-five minutes before sunrise during the first ten days of the month. A fainter object would be lost in the Sun's glare already, but at magnitude –3.9 Venus is able to shine through the bright predawn twilight.

On September 14 Venus lies 3° north of Mercury, which is then coming into the predawn sky for its best morning apparition of the year. At magnitude 2.3, Mercury is by far the fainter of the two. You'll

MERCURY'S BEST MORNING APPARITION of 1990 occurs in late September when the planet climbs to 10° above the eastern horizon thirty minutes before sunrise.





VENUS MEETS REGULUS on the morning of September 6. The two objects lie 1° apart low in the eastern sky about thirty minutes before the Sun rises.

have a better chance to see the pair on September 17, when Mercury is sandwiched between Venus and the waning crescent Moon, but you'll still need binoculars to see them well.

Mercury goes on to brighten significantly and climb higher in the predawn sky, with greatest elongation occurring on September 23/24. It will remain in the sky through the first week of October.

SEPTEMBER'S STARRY SKY

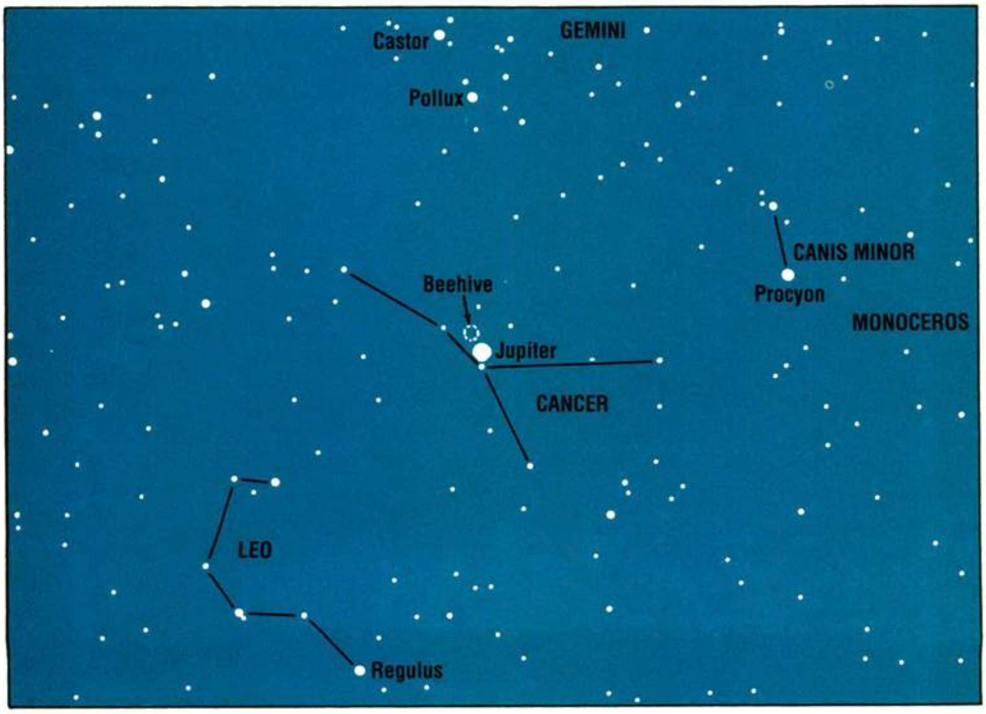
Chance juxtapositions of objects in the sky provide a good opportunity for thinking three-dimensionally. Jupiter, a planet in our solar system, is only about 47 light-minutes from Earth in late September. Meanwhile, the center of the Beehive star cluster — visible near Jupiter in late September — is estimated by modern astronomers to be some 520 light-years away.

If you view Jupiter this month from a location far from city lights, you'll notice the Beehive in its vicinity. Binoculars bring this cloudy patch into better view. The older name Praesepe is Latin for "the manger." The more modern name, the Beehive, stems from English skylore.

This cluster is inconspicuous unless you know right where to look for it. It is at the center of the dim constellation Cancer the Crab, which lies between Leo and Gemini in the evening sky of late winter and early spring and in the morning sky at this time of year. Although the stars of Cancer are faint, the constellation is very ancient. In Greek skylore, the Crab was sent by the queen of the gods, Hera, to bite the foot of Hercules. The great hero was busy battling the legendary serpent, Hydra, and he simply crushed the little crab with his foot. Soon afterward, however, Hera transported the crab to the sky.

In about 1600, the Beehive cluster appeared on a star chart under the designation "Nubilum," or "Cloudy One." It's possible no one realized that it contained stars until 1610, when Galileo peered at the cluster through his early "optick tube." He later wrote of "the nebula called Praesepe, which is not one star, only, but a mass of more than forty small stars." The sight of these stars, in a universe thought to be bounded by crystal spheres, is said to have filled Galileo with wonder.

THE BEEHIVE STAR CLUSTER in Cancer is relatively easy to find this month. In late September this beautiful binocular object lies just 2° north of Jupiter in the eastern sky before dawn.



Your first look at the Beehive through binoculars may be just as wonderful. It is a swarm of suns; several hundred stars are known to be physical members of the Beehive. It is an open, or galactic, star cluster, which means that its stars were born together from a vast cloud of gas and dust in interstellar space. Although they're still weakly bound by gravity, the stars in the Beehive won't stay together permanently. Gravitational interactions between stars in the cluster — and between the cluster and the Galaxy at large — will eventually kick these stars out of the cluster and send them drifting out on their own. □

Deborah Byrd is the creator, writer, and producer of "Star Date," a syndicated radio series on commercial and public radio.

Through the Eyepiece by *Rick Shaffer*

A COMET TO SURPASS AUSTIN?

The second naked-eye comet of 1990 should put on a good show in the evening sky during August and early September. Expectations for Comet Levy aren't running quite as high as they did for Comet Austin last spring, but then again astronomers think Levy will come closer to matching their predictions than its famous predecessor did. (See "Comets Encke and Levy: Something Old and Something New" on page 66 for more details on Comet Levy and its observability.)

Because Comet Levy never gets very close to the Sun — its perihelion distance is a substantial 0.94 AU — it will probably not develop a spectacular tail. Instead, expect Levy to look like a big fuzzball similar to 1983's Comet IRAS-Araki-Alcock or even Comet Austin during May.

During the period leading up to New Moon on August 20 Comet Levy is located in Pegasus, but it moves rapidly south and west into Sagittarius by month's end. It is there that the comet should peak in brightness, at about 4th magnitude. Perhaps the most interesting conjunction takes place on August 18 when Levy passes within 1° of the globular cluster M15. Several interesting conjunctions occur when Levy is in Sagittarius, but unfortunately the Moon is bright and in the sky at that time. On September 1 the comet passes 1° south of the open cluster M25 and on September 4 it passes less than 1° from M8, the Lagoon Nebula. (Use the map or table of coordinates at right to follow the comet's progress through Sagittarius.)

COORDINATES FOR COMET LEVY

Date	R.A. (2000)	Dec.
Aug. 30	18h48.9m	−17°26'
Aug. 31	18h36.5m	−19°29'
Sept. 1	18h24.6m	−21°22'
Sept. 2	18h13.2m	−23°04'
Sept. 3	18h02.3m	−24°38'
Sept. 4	17h52.0m	−26°02'
Sept. 5	17h42.3m	−27°18'
Sept. 6	17h33.1m	−28°27'

MERCURY'S EVER-CHANGING APPEARANCE

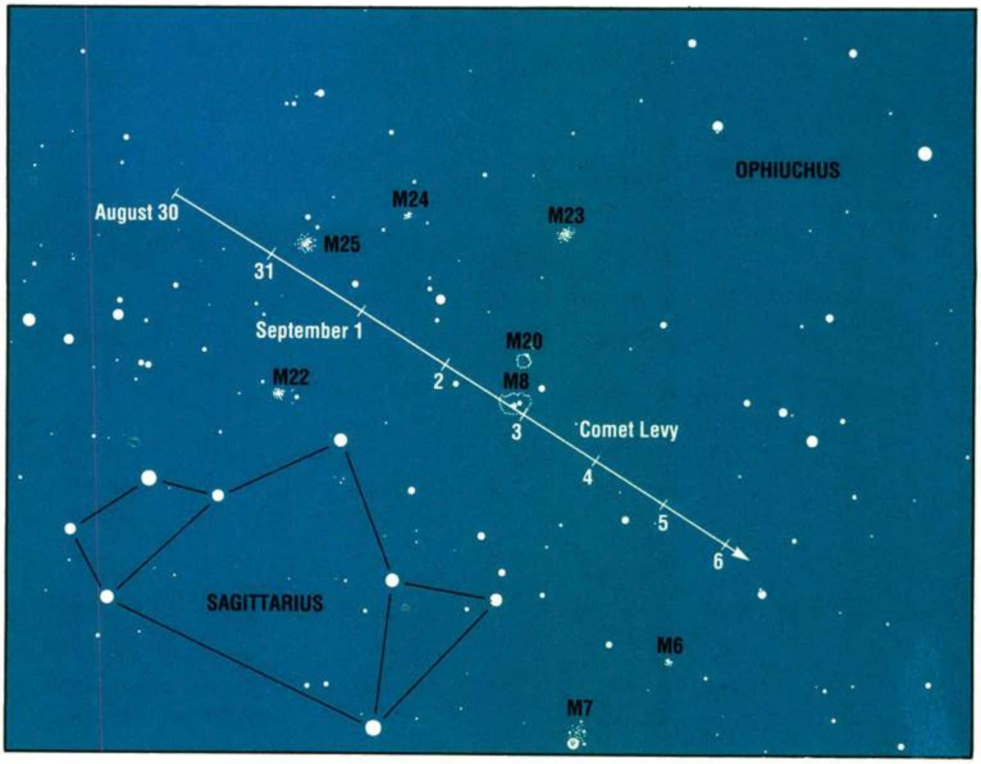
Mercury makes its best morning apparition of 1990 for observers in the Northern Hemisphere this month. Greatest elongation occurs on September 23/24, when the planet lies 17.9° west of the Sun, but you should be able to spot the elusive planet as early as the 14th. On that day Mercury is just 3° south of Venus in the predawn sky. Three days later Mercury lies only 2° north of a very thin waning crescent Moon.

By using Venus and the Moon as guides, you can find Mercury on any morning between the 14th and 17th. When you do, take time to compare the pale yellow color of Mercury's disk with the pure white of Venus and the Moon's gray-green hue.

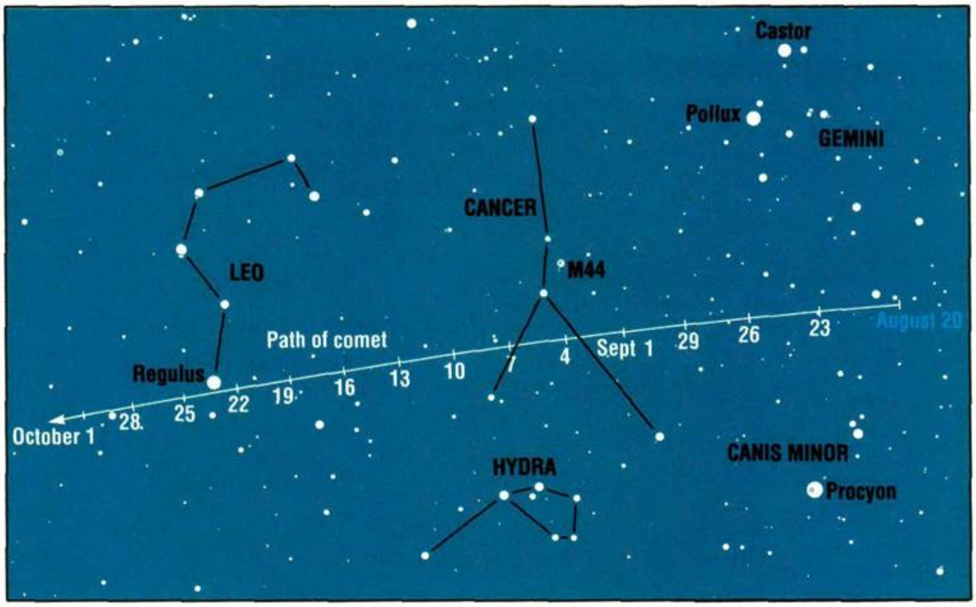
If you have a morning with excellent seeing, you might glimpse a slight darkening near Mercury's terminator (the dividing line between day and night). This is caused by sunlight being scattered by craters near the terminator. Because the light strikes those craters at a grazing angle, they scatter more sunlight than do craters farther into the daylight side of the planet. But even if you aren't blessed with great seeing conditions this month, the rapid changes in Mercury's apparent size, brightness, and illumination offer plenty for the early morning observer.

On the 14th Mercury glows

COMET LEVY PASSES THROUGH the rich starfields of Sagittarius in early September, where it has several interesting conjunctions with Messier objects. Positions are shown at 11 p.m EDT (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT).



relatively dimly at magnitude 2.3 and reveals a large, thin crescent — 9.4" in diameter and only 10-percent lit. By the 17th Mercury's apparent diameter has shrunk to 8.7" and its illuminated portion has swelled to 19 percent; these combine to make the planet significantly brighter, shining at magnitude 1.2. At greatest elongation on September 23/24 Mercury is a –0.4-magnitude object with a 7.1"-diameter, 49-percent-lit disk. And by the end of September Mercury has brightened to magnitude –0.9, though its disk is then only 6.1" across and is illuminated 74 percent.



MORE CHALLENGING THAN LEVY, Comet Honda-Mrkos-Pajdusakova can be found in the eastern sky on mornings in late August and September. Positions are shown at 6:30 a.m. EDT (5:30 a.m. CDT, 4:30 a.m. MDT, and 3:30 a.m. PDT).

COORDINATES FOR COMET HONDA-MRKOS-PAJDUSAKOVA

Date	R.A. (2000)	Dec.
Aug. 20	7h12.5m	15°50'
Aug. 23	7h33.1m	16°01'
Aug. 26	7h51.4m	16°03'
Aug. 29	8h08.2m	15°59'
Sept. 1	8h23.9m	15°48'
Sept. 4	8h38.9m	15°31'
Sept. 7	8h53.5m	15°08'
Sept. 10	9h07.7m	14°39'
Sept. 13	9h21.8m	14°05'
Sept. 16	9h35.7m	13°25'
Sept. 19	9h49.3m	12°40'
Sept. 22	10h02.6m	11°52'
Sept. 25	10h15.5m	11°01'
Sept. 28	10h28.0m	10°08'
Oct. 1	10h39.9m	9°14'

THE MOON AND PLEIADES

Following close on the heels of the excellent lunar occultation of the Pleiades in August, another occultation of the Pleiades greets observers on the morning of September 10. And whereas last month's occultation was best seen from eastern and central North America, this month's occultation is best seen from western North America and Hawaii. In fact, the farther north and west you are on the North American continent, the more closely the Moon passes through the bowl of the Seven Sisters' pseudo Little Dipper.

The Moon is 65-percent lit as it traverses the cluster shortly before dawn on the 10th. (In eastern North America the Sun rises before the occultation begins, and observers there will have to be content with seeing the Moon approach the cluster's western edge before dawn.) The illuminated portion of the lunar disk leads the way as the Moon crosses the Pleiades. You'll have a more difficult time observing the cluster members as they disappear behind the Moon's bright limb than watching them reappear from behind the Moon's unlit hemisphere.

A PAIR OF FAINTER SEPTEMBER COMETS

In addition to Comet Levy, which is expected to reach naked-eye visibility in September, two other comets should be bright telescopic objects this month. Both Comet Honda-Mrkos-Pajdusakova and Comet Encke are morning objects in September, so by adding them to your observing list you can view comets all night long!

The best times to observe Comet Honda-Mrkos-Pajdusakova are during the last two weeks of both August and September, when the Moon is gone from the morning sky. The comet moves eastward at about the same rate as the Sun does throughout this period and so remains in nearly the same position in the morning sky. Look for H-M-P approximately 20° above the eastern horizon at the beginning of nautical twilight. The comet should glow at around 8th or 9th magnitude and its tail will point perpendicularly to the horizon.

At the beginning of the August observing window Comet H-M-P is located in the constellation Gemini, but by September 1 it has moved into Cancer. Shortly after it reaches perihelion on September 12 (at a distance from the Sun of 0.54 AU) the comet moves into Leo, where it remains for the rest of the month. Use the chart or table of coordinates above to locate H-M-P during August and September.

Comet Encke is the second periodic comet to grace the morning sky in September. Encke has the shortest period of any comet — 3.3 years — and has been observed at every return since 1822 with the exception of 1944, when astronomers were otherwise engaged.

The best time to observe Comet Encke is during the Moon-free period in the last half of September. Shortly before twilight begins, the comet is high in the east and is expected to be glowing softly at 8th magnitude. (See "Comets Encke and Levy: Something Old and Something New" on page 66 for more details on Comet Encke's apparition this month and next.)

TELESCOPIC PLANETS

Venus is visible low in the east before sunrise during the first three weeks of September. The planet is still very bright at magnitude –3.9, but the featureless disk offers little for the telescopic observer. The most interesting events for Venus this month are close approaches to other objects. On September 6 Venus passes just 0.8° north of the 1st-magnitude star Regulus and on September 14 it lies 3° north of Mercury.

By the end of September Mars is only two months away from a favorable opposition, so now is the time to begin serious observations of the Red Planet. On September 1 its disk measures 11.0" across, but it grows by 2.5" during the course of the month. Over the same span it brightens by 0.5 magnitude, from magnitude –0.4 to –0.9. With Mars this large and this bright, a 4-inch or larger telescope should reveal a number of surface features. (See "The Red Planet's Return to Glory" on page 74 for more information on Mars' 1990 apparition.)

Jupiter now rises well before morning twilight begins and is getting well placed for telescopic observation. It was just over a year ago, when Jupiter emerged in the morning sky after conjunction, that observers realized the planet's South Equatorial Belt had nearly disappeared. No one knows when the Belt will return or whether Jupiter holds any similar surprises this year, but it certainly bears watching. This month Jupiter's disk spans 33.4" and glows at magnitude –1.9.

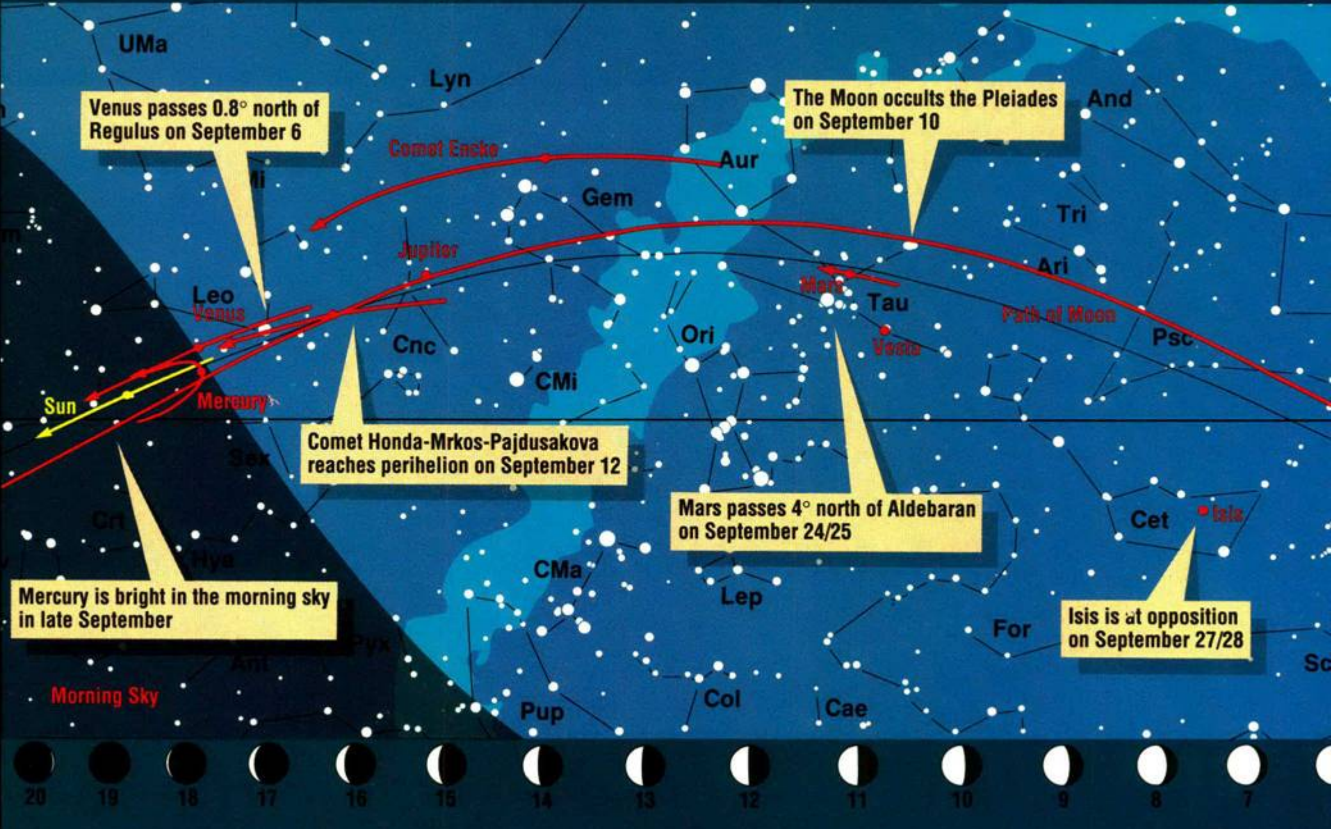
The ringed planet Saturn lies due south and is thus highest in the sky as evening twilight ends in September. The 0.4-magnitude planet measures 17.4" across its equator and its rings are over twice that size — 39.7" in diameter. Observe Saturn early in the evening; as it sinks lower in the southwest the increasingly murky atmosphere causes the view to deteriorate rapidly.

Saturn's neighbors — Uranus and Neptune — benefit from the same observing strategy: the earlier you start observing, the better. This month Uranus' blue-green disk measures 3.7" in diameter and glows at magnitude 5.7. Neptune's 7.9-magnitude, 2.2"-diameter disk displays a subtle blue-gray color. □

Rick Shaffer is a technical group leader at the Jet Propulsion Laboratory in Pasadena, California. He is also a telescope and Frisbee nut, owning more than a few of both.

THE PLEIADES ARE OCCULTED by a gibbous Moon on the morning of September 10, with the best views coming from western North America. Photo of the April 8, 1989, occultation by James Smallwood.

The Solar System September 1990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Venus passes 0.8° north of Regulus on September 6

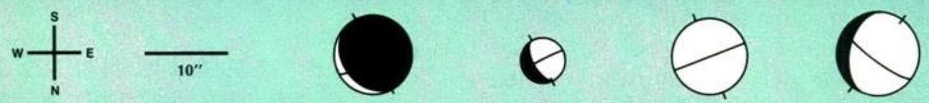
The Moon occults the Pleiades on September 10

Comet Honda-Mrkos-Pajdusakova reaches perihelion on September 12

Mars passes 4° north of Aldebaran on September 24/25

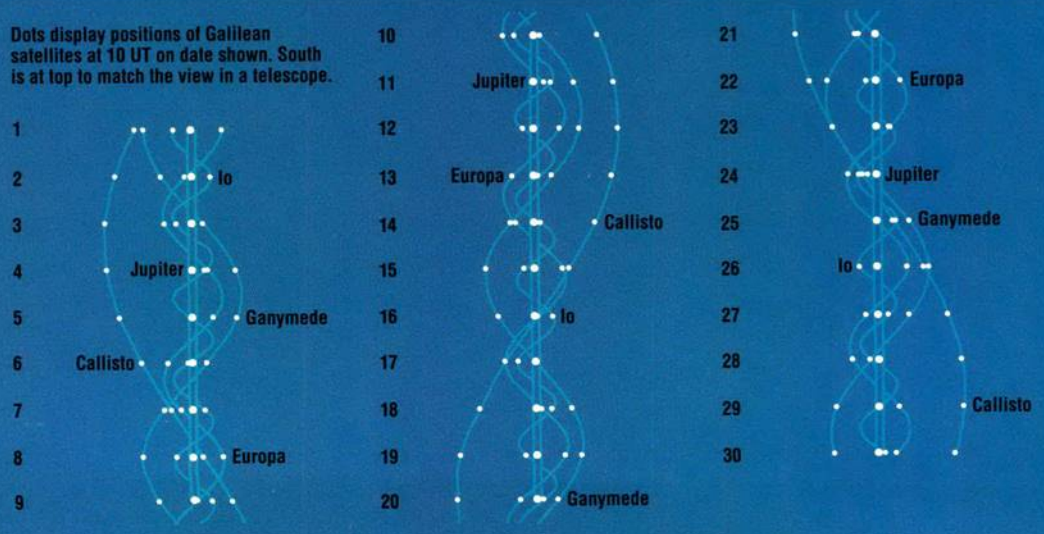
Mercury is bright in the morning sky in late September

Isis is at opposition on September 27/28

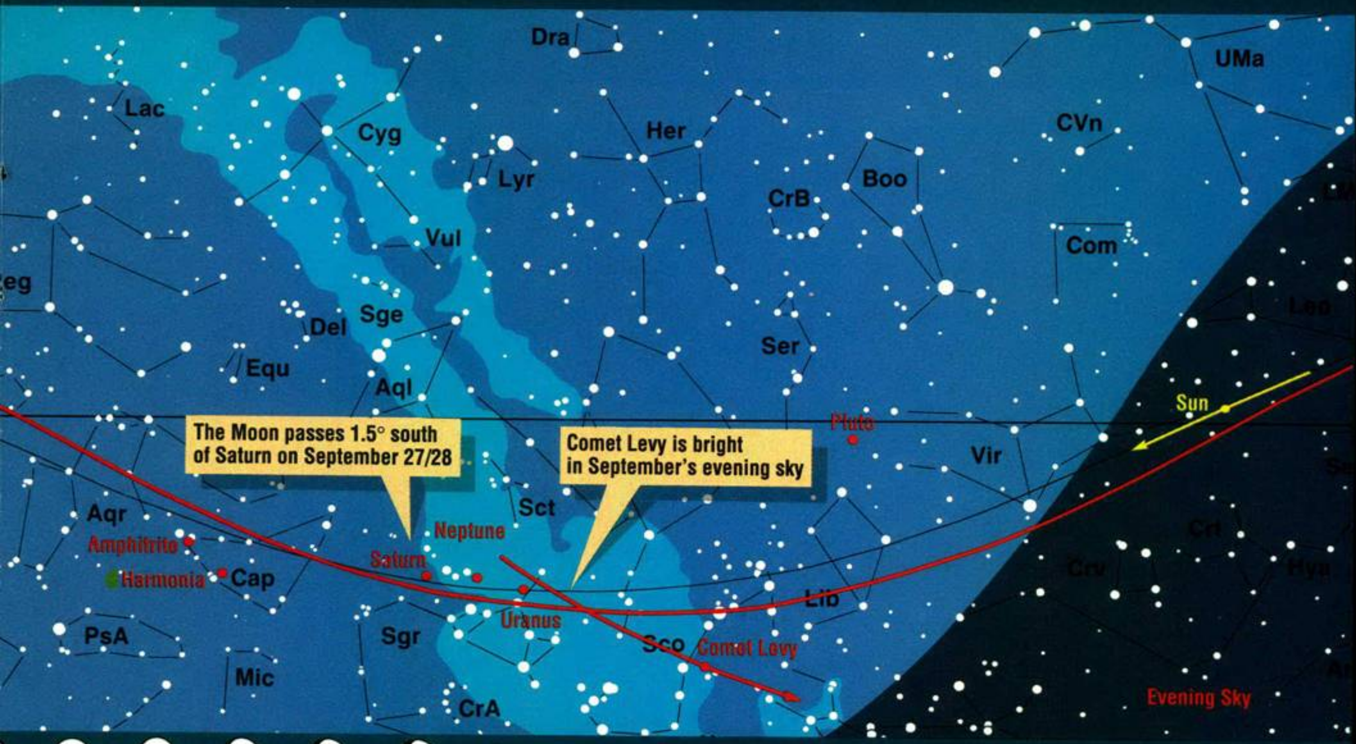


Planet	MERCURY	MERCURY	VENUS	MARS	MARS
Date	September 1	September 30	September 15	September 1	September 30
Magnitude	+2.5	−0.9	−3.9	−0.4	−0.9
Angular Size	10.4"	6.1"	10.0"	11.0"	13.5"
Illumination	10%	74%	98%	85%	89%
Distance (AU) from Earth	0.645	1.111	1.667	0.851	0.691
Distance (AU) from Sun	0.413	0.315	0.719	1.408	1.436
Right Ascension (2000.0)	11h22.3m	11h28.4m	10h46.7m	3h54.4m	4h41.6m
Declination (2000.0)	−0°49'	5°17'	9°12'	18°32'	21°05'

Jupiter's Moons



Dots display positions of Galilean satellites at 10 UT on date shown. South is at top to match the view in a telescope.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Vir
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Crt
Harmonia
Cap
Crv
Hya
Lib
Uranus
PsA
Sgr
Sco
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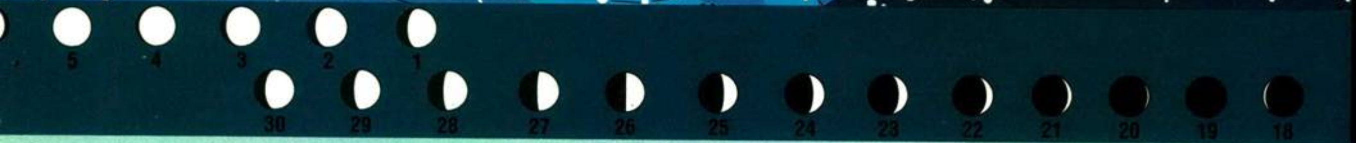
Mic
CrA
Evening Sky

The Moon passes 1.5° south of Saturn on September 27/28

Comet Levy is bright in September's evening sky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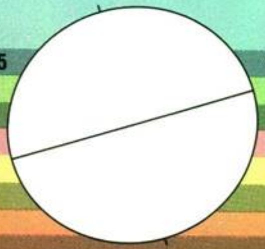
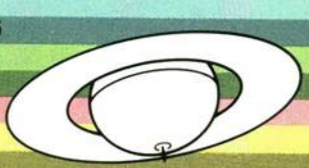
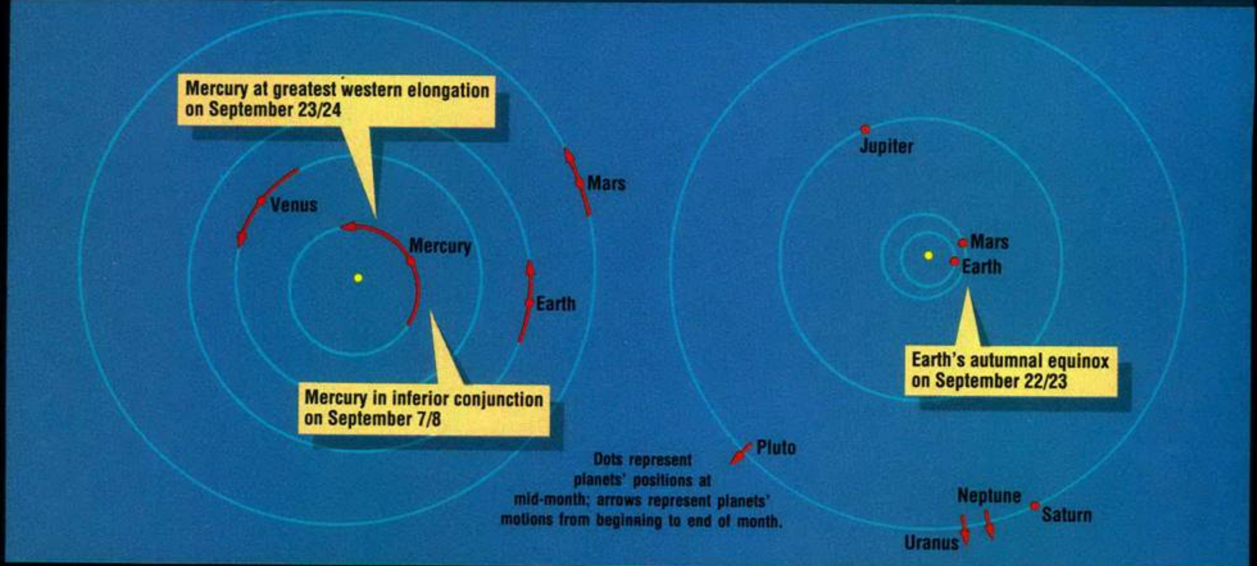



JUPITER September 15	SATURN September 15	URANUS September 15	NEPTUNE September 15	PLUTO September 15
−1.9	+0.4	+5.7	+7.9	+13.8
33.4"	17.4"	3.7"	2.2"	0.1"
100%	100%	100%	100%	100%
5.887	9.509	19.163	29.847	30.225
5.244	10.004	19.426	30.205	29.662
8h32.5m	19h21.8m	18h25.0m	18h51.6m	15h10.6m
19°11'	−22°07'	−23°38'	−22°04'	−2°08'

The Planets in Their Orbits


Venus
Mercury
Mars
Earth
Jupiter
Mars
Earth
Pluto
Neptune
Saturn
Uranus

Mercury at greatest western elongation on September 23/24

Mercury in inferior conjunction on September 7/8

Earth's autumnal equinox on September 22/23

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

Fuji's Miraculous Super HG 400

A new color negative film offers high speed, outstanding color rendition, and extremely fine grain.

by Tony Hallas and Daphne Mount

The search for the perfect color film for astrophotography may be over. Last spring Fuji quietly introduced Super HG 400, a high-speed color negative film made for high-definition color photography.

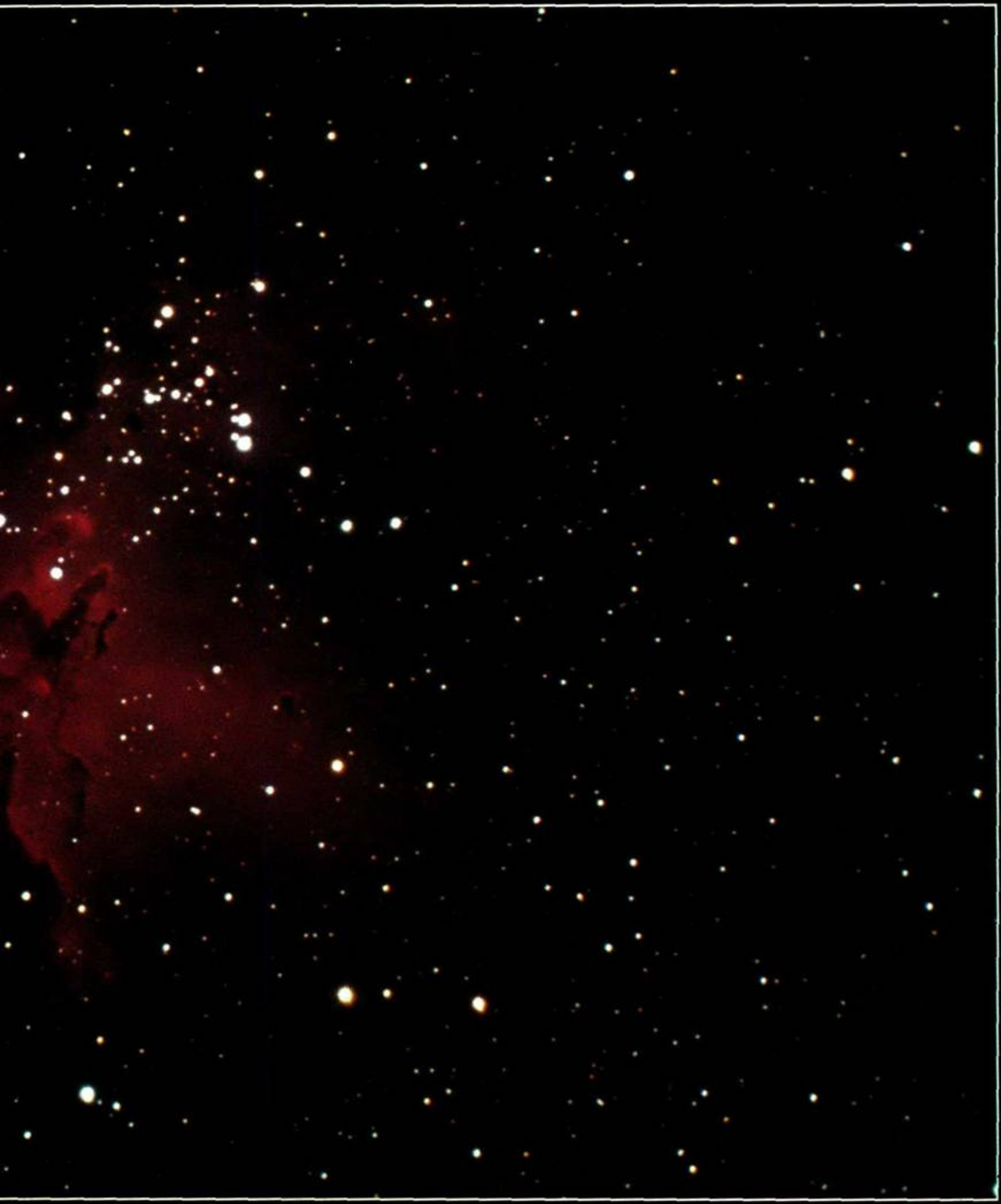
To test the film on astronomical subjects, we took pictures from a dark sky site on Mount Pinos, well away from the lights of Los Angeles. During two moonless periods last spring we shot long exposures with the film, using a 14-inch f/11 SCT (more often than not converted to f/7.5 to gain a wide field) and a 6-inch f/8 EDF apochromatic refractor. Our testing shows that the film records deep-sky objects astonishingly well in exposures ranging from 5 minutes to 45 minutes. To maximize film sensitivity, we hypersensitized our rolls of HG 400 on an open reel in the normal mixture of 8 percent hydrogen forming gas for approximately one day.

Super HG 400 does a remarkable job of recording ruddy objects like emission nebulae, planetary nebulae, and supernova remnants. To photograph the Eagle Nebula in Serpens (M16), the Trifid Nebula in Sagittarius (M20), and the Ring Nebula in Lyra (M57), we employed the 14-inch SCT at f/7.5. To gain the wider field required for a photo of the Orion Nebula (M42), we used the 6-inch f/8 refractor.

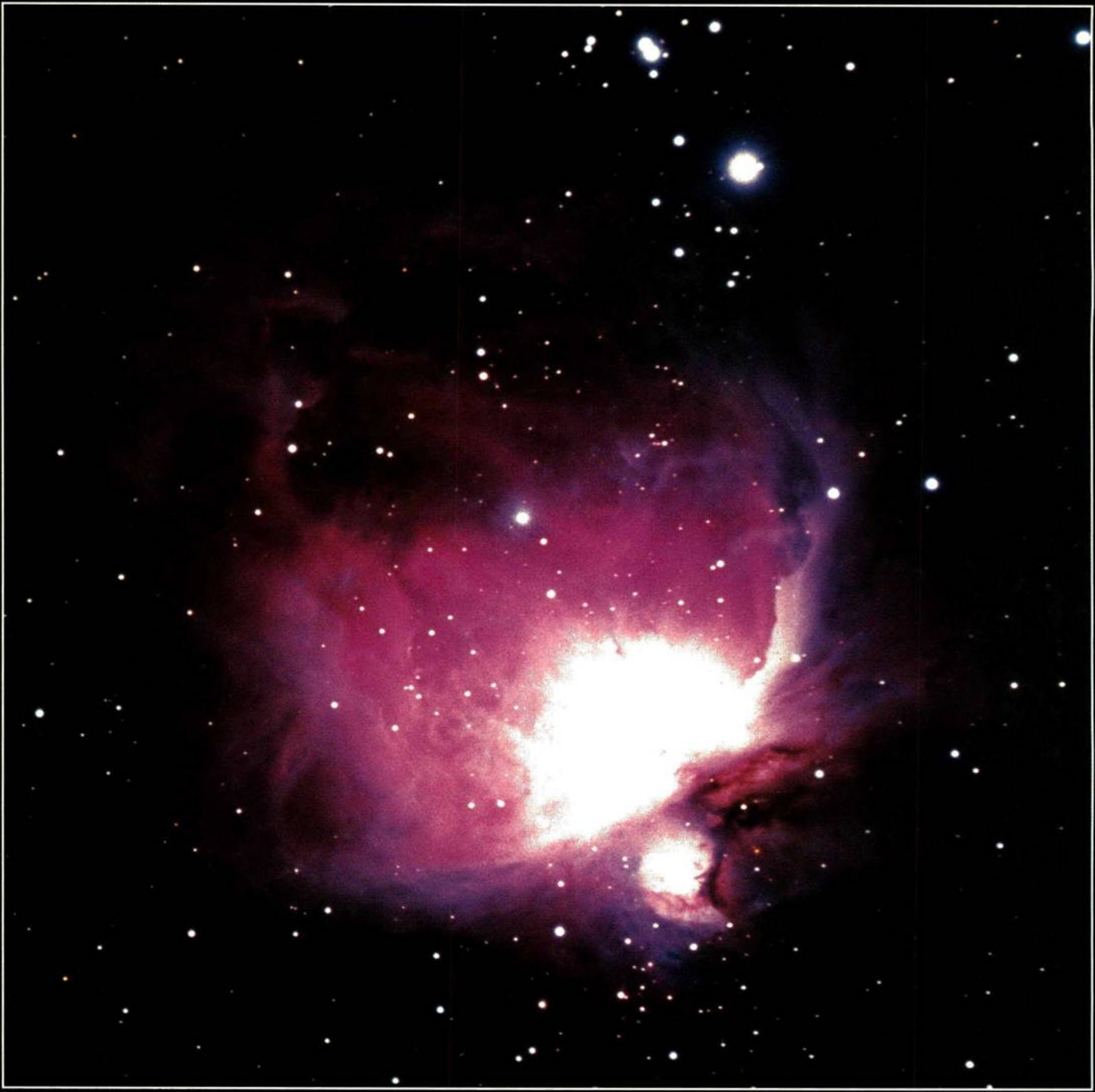
The Eagle photo shows a great deal of faint nebulosity fanning outward from the central star cluster that causes the nebula to shine. The *Trifid* Nebula shot, a 25-minute exposure, records subtle blushes of pink seemingly intertwined with the multicolored star background. Unlike many Trifid photos, the photo produced on HG 400 shows the Trifid's bluish reflection nebulosity as strongly as the red emission glow (See the cover.) To capture the Ring Nebula, an object with a very high

The Hercules Cluster, M13

The Ring Nebula in Lyra, M57



The Eagle Nebula
in Serpens, M16



The Orion Nebula, M42

Galaxy M81 in Ursa Major

surface brightness, we needed only a 5-minute exposure. A large contrast range exists in the Orion Nebula photo, from stark white through strong purples and down to pretty, soft pink.

"Straight," unhypersensitized photos made with HG 400 are very contrasty and record colors nicely. To maximize color and contrast, however, we made two identical exposures of each object and "stacked" the negatives in an enlarger for copying onto a single film chip. This yields tremendously high contrast and richer colors than single shots can deliver.

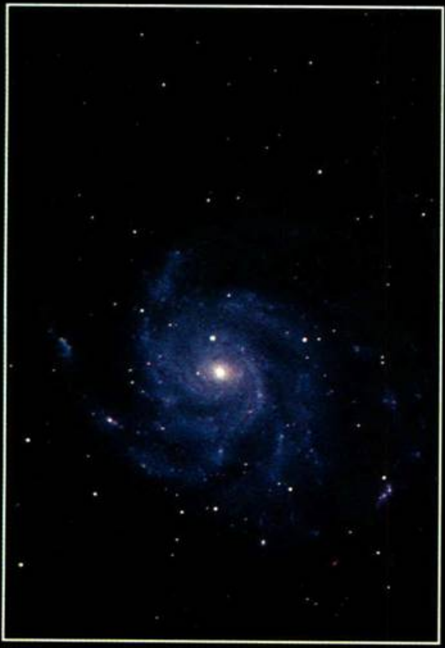
Fuji's new film records star images very nicely because of its high contrast and fine grain. A 20-minute exposure of the Hercules Cluster (M13) made with the 14-inch f/7.5 SCT shows a blazing central bulge resolved into pinpoints across the center and surrounded by myriad gleaming white stars. (This photograph is also reproduced on the cover of the August issue.)

Perhaps the most pleasant surprise is that HG 400 capably records not only red objects but also blue objects, as demonstrated by the Trifid. The film's dual ability allowed us to photograph the galaxies M51, M81, and M101 with the 14-inch f/7.5 SCT. (The respective exposures were 45, 50, and 50 minutes.) In each case the film recorded a yellowish-white nucleus, beautifully defined bluish spiral arms, and fine detail associated with each galaxy, such as knots in the spiral arms and extensive dark nebulosity.

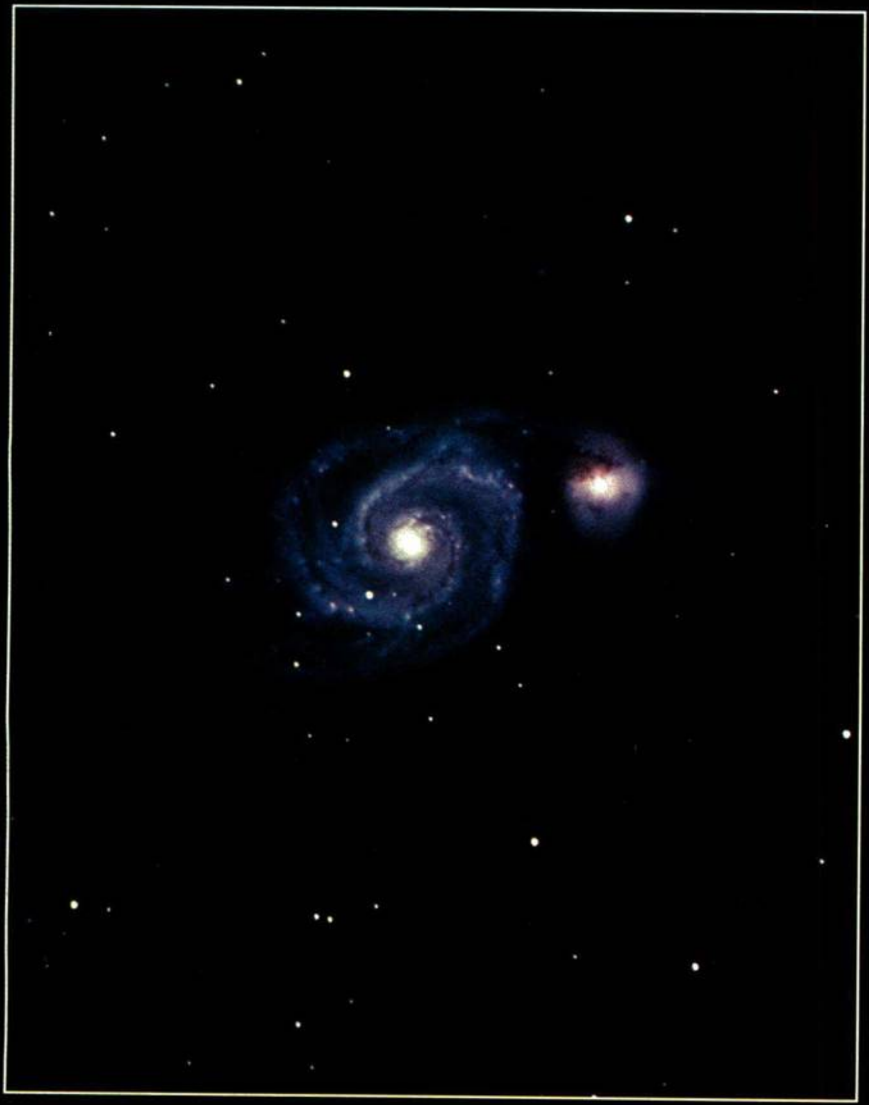
Fuji's Super HG 400 was designed for taking color prints of the kids. However, its attributes also make it the best color film we've ever used for recording astronomical subjects. Super HG 400 is fast, has low reciprocity failure, displays good color balance and high contrast, is sensitive to red and blue light, hypersensitizes well, and has a very fine grain structure. In our opinion, because of this uniquely powerful combination of characteristics, this film will play a central role in the immediate future of color astrophotography.

We've just begun to experiment with Fuji's Super HG 400. But a mere few weeks of testing have clearly shown that astrophotographers who use color negative film are in for the treat of their lives. □

Tony Hallas and Daphne Mount are avid astrophotographers living in Oakview, California.



Galaxy M101 in Ursa Major



The Whirlpool Galaxy, M51

Comets Encke and Levy: Something Old and Something New

Two comets — one the most frequently observed of all and the other an apparent new-comer — promise to make late summer and early autumn an exciting time for backyard observers.

by Charles S. Morris

At this very moment, two tiny members of our solar system are rushing toward the Sun. As they move ever closer to our star, the heat from the Sun warms their icy surfaces, turning the ice into gas and liberating large quantities of dust in the process. The gas and dust form vast halos surrounding these iceballs — comets! — that will grace our skies in the coming months.

But the two comets have different histories and will put on quite different shows. Periodic Comet Encke, which has made dozens of recorded passages through the inner solar system, will give an encore performance in September and October for Northern Hemisphere observers. Encke will come close to naked-eye visibility and should display an unusual fan tail that appears to point toward the Sun. Newly discovered Comet Levy, on the other hand, is making its first known trip into the Sun's vicinity. Levy is visible right now and will remain visible several months longer than Comet Encke. It also holds promise of being brighter than the much publicized and somewhat disappointing Comet Austin.

The Return of Encke

Comet Encke has the shortest orbital period and the second smallest perihelion distance of any known short-period comet. It also has been observed at more perihelion passages (over fifty) than any other comet, including Comet Halley. The frequency of these passages has led astronomers to use observations of Encke for testing theories of the physical properties and evolution of comets in general.

The comet was first sighted low in the western sky on the evening of January 17, 1786, by French observer Pierre Mechain. Unfortunately, the comet was seen only once more during that apparition, and thus its orbit could not be calculated.

Nearly ten years after Mechain's initial discovery, in November 1795, Caroline Herschel discovered the cometary interloper again. This time observations stretched over a three-week period, but astronomers could not fit a parabolic orbit — the type of orbit a comet on its first visit to the inner solar system would have — to the comet's positions.

Yet another ten years elapsed before the comet was seen again. On October 19, 1805, three comet hunters — Pons, Huth, and Bouvard — independently found the comet within hours of each other. Based on a month's worth of observations, several astronomers tried calculating parabolic orbits, while Johann Franz Encke derived an elliptical orbit (for a returning comet) with a period of about twelve years that he believed better fit the comet's observed positions.

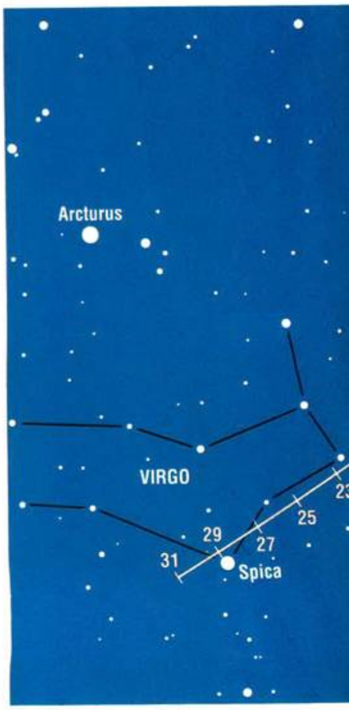
The next sighting came in November 1818, when Pons discovered the comet for the second time, and astronomers followed its progress for about seven weeks. Encke soon realized that no parabolic orbit would fit the observations, and he decided to use a new method for determining elliptical orbits developed by the German mathematician Karl Friedrich Gauss. The resulting orbit had a period of 3.3 years.

There was still no link between the comet of 1818 and the earlier comets, however. To settle the matter, Encke calculated the comet's orbit back in time, taking into account perturbations from the planets. Encke then went on to predict that the comet would next return in 1822. When it did, the comet became known as Encke's Comet.

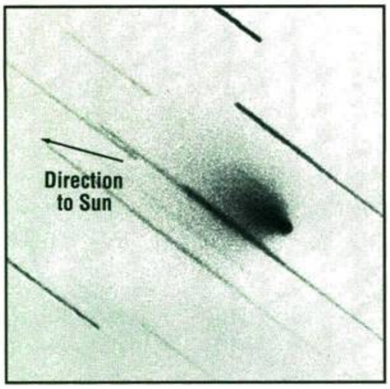
The orbit of Comet Encke produces an interesting and unusual set of observing circumstances. The comet travels around the Sun in the same direction as Earth does in an orbit inclined about 12° to the plane of Earth's orbit. As the comet orbits through the inner solar system, it slides from north to south of the ecliptic.

These circumstances mean Northern Hemisphere observers see the comet almost exclusively prior to perihelion and Southern Hemisphere observers see it after perihelion. Because its perihelion distance is so small — only 0.33 astronomical units (AU) — Encke always lies within 20° of the Sun at perihelion and is then extremely difficult to observe.

The time of year Encke reaches *perihelion* determines when the



comet can be seen and whether or not the apparition will be favorable. This year perihelion occurs on October 28, which produces a favorable morning apparition for Northern Hemisphere observers. Unfortunately for Southern Hemisphere observers, the comet remains within 15° of the Sun for several months after perihelion and will not be observable.



ENCKE'S DUSTY SUNWARD FAN TAIL appears prominent in this 1980 image by S. Djorgovski and H. Spinrad. Image courtesy H. Spinrad.

Comet Encke, more than any other comet, provides reseachers with the opportunity to study a comet's evolution. Encke himself realized by the mid-1800s that something was "wrong" with the comet that bears his name. According to the laws of orbital mechanics established by Isaac Newton, it should be possible to calculate the return of a periodic comet precisely if all gravitational effects from the planets are accounted for. But Comet Encke was arriving at perihelion about three hours earlier than expected at each apparition.

We now know that these "nongravitational forces" are caused by jets of dust and gas shooting out from the comet's nucleus. The jets act on the small nucleus like rocket thrusters. Similar jetting action can either lengthen or shorten a comet's orbital period, depending on which direction the nucleus rotates with respect to the comet's orbital motion.

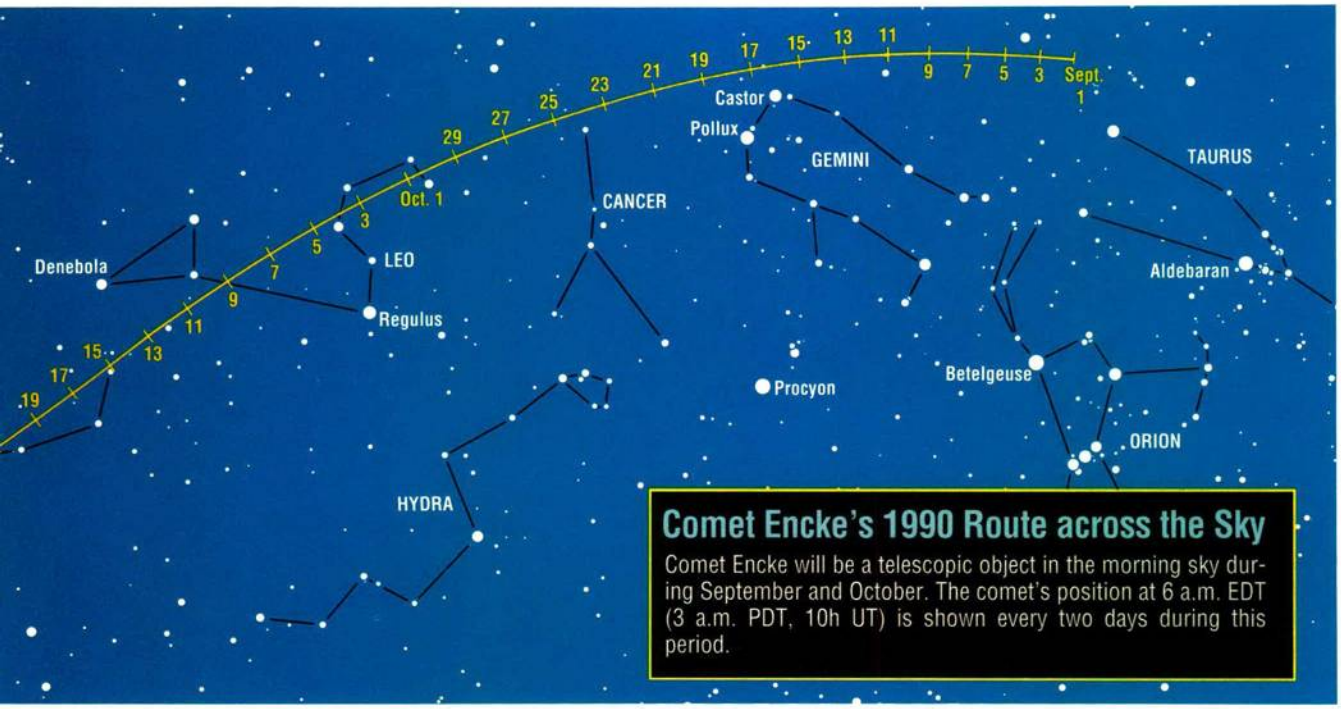
A Sunward Tail

One observable result of this jetting action is that Comet Encke displays a Sunward fan tail. Most comets have tails that point away from the Sun. But some comets, and most notably Encke, display an elongation or fan that points toward the Sun. In Encke's case, the fan is primarily seen before the comet reaches perihelion.

Zdenek Sekanina of the Jet Propulsion Laboratory has proposed that Encke's preperihelion Sunward fan can be explained by gas and dust spewing forth from a single vent located at a high latitude on the comet's nucleus. As the nucleus rotates, this material spreads out into a cone that usually projects on the sky as a fan-shaped extension toward the Sun. However, at times this cone of material points toward Earth and the fan disappears. Sekanina predicts that during the 1990 apparition the Sunward fan will disappear in early October, about twenty days before perihelion.

Another characteristic of Comet Encke is its unique visual light curve, the variation in the intrinsic brightness of the comet's coma as it approaches and recedes from the Sun. The light curves from several recent apparitions illustrate this characteristic and give a good indication of how Encke should behave this year. As Encke approaches the Sun and comes into range of amateur telescopes, it brightens rapidly. However, the rate of brightening decreases as the comet nears the Sun. During the last few weeks before perihelion the comet brightens very slowly, peaking about a week after perihelion. It then fades rapidly over the following two weeks, after which the rate of fading slows.

Comet Encke's light curve also seems to be evolving: the comet was nearly a magnitude brighter in 1984 than it was in 1980. The magnitude predictions which follow are based on the average of these two apparitions, and thus the comet could easily be half a magnitude brighter or fainter than the quoted values.



Comet Encke's 1990 Route across the Sky

Comet Encke will be a telescopic object in the morning sky during September and October. The comet's position at 6 a.m. EDT (3 a.m. PDT, 10h UT) is shown every two days during this period.

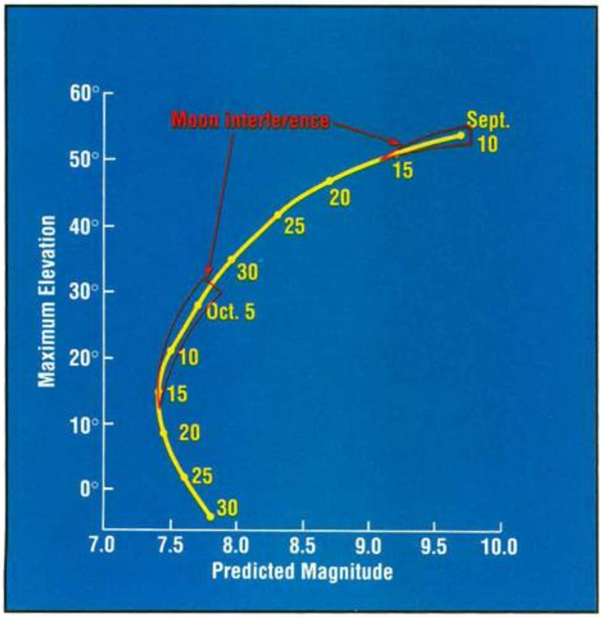
Observing Prospects for Encke

By September 10 Comet Encke should brighten to about 10th magnitude, at which time you can spot it with 20x80 binoculars or a 6-inch telescope. As the Moon wanes in mid-September, Encke is expected to glow between magnitudes 9.0 and 10.0, and the comet will be well placed in the morning sky. Its coma should appear several arcminutes across and will be slightly brighter in the center, but you won't see the classic star-like condensation typical of most bright comets. Expect the coma to be elongated, or even parabolic, with the parabola opening in the direction of the Sun. This is Comet Encke's famous Sunward fan tail. The fan should be quite broad and will be seen best in 6-inch or larger telescopes.

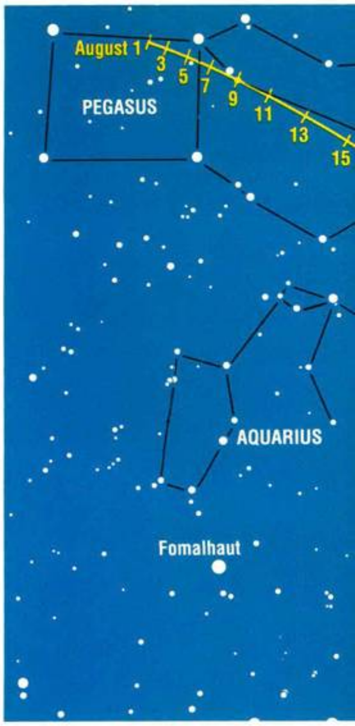
At New Moon on September 18/19, Encke sits near the intersection of Gemini, Cancer, and Lynx. Near 9th magnitude then, the comet should be an easy target from a dark-sky site for observers with large binoculars. The comet will appear as a large diffuse glow, perhaps 10' in diameter.

By the end of September Comet Encke lies just below Mu Leonis, the star at the top of the Sickle asterism that forms the great lion's head. The comet has brightened to about magnitude 7.9, and at the beginning of astronomical twilight (around 5:30 a.m. local daylight time) is a respectable 35° above the eastern horizon.

In binoculars the comet's coma will still appear big — 10' in diameter or larger. A faint, narrow gas tail up to 1° long, pointing directly away from the Sun, may also be glimpsed. Through a telescope, the comet will appear more condensed; that is, there will be a more obvious brightening toward the center of the coma. The Sunward fan will be less obvious at this time and, by Sekanina's prediction, will disappear altogether by October 8 as the cone of the fan points toward Earth. October 2 will be the last morning to observe Encke before the nearly Full Moon interferes.



COMET ENCKE IS HIGH IN THE SKY and shines at 10th magnitude as astronomical twilight begins in mid-September. With each passing day the comet's elevation in a dark sky decreases and, until mid-October, its brightness increases. The view of Encke is best when the Moon is out of the sky.



During the Full Moon period in October, Encke will undergo a remarkable transformation. The coma will rapidly shrink and become much more condensed, or star-like, in appearance. The comet will also sink rapidly toward the eastern horizon with each passing day, making it more of a challenge to observe. By the morning of October 11 the comet lies just over 1° south of M65 in Leo, but it is only 20° above the eastern horizon as twilight begins. For the next ten days, binoculars will show the comet as a fuzzy, 7.5-magnitude star. Keen-eyed observers may spot the short, elusive gas tail. In a telescope, the head of the comet will look round and the Sunward fan will no longer be visible.

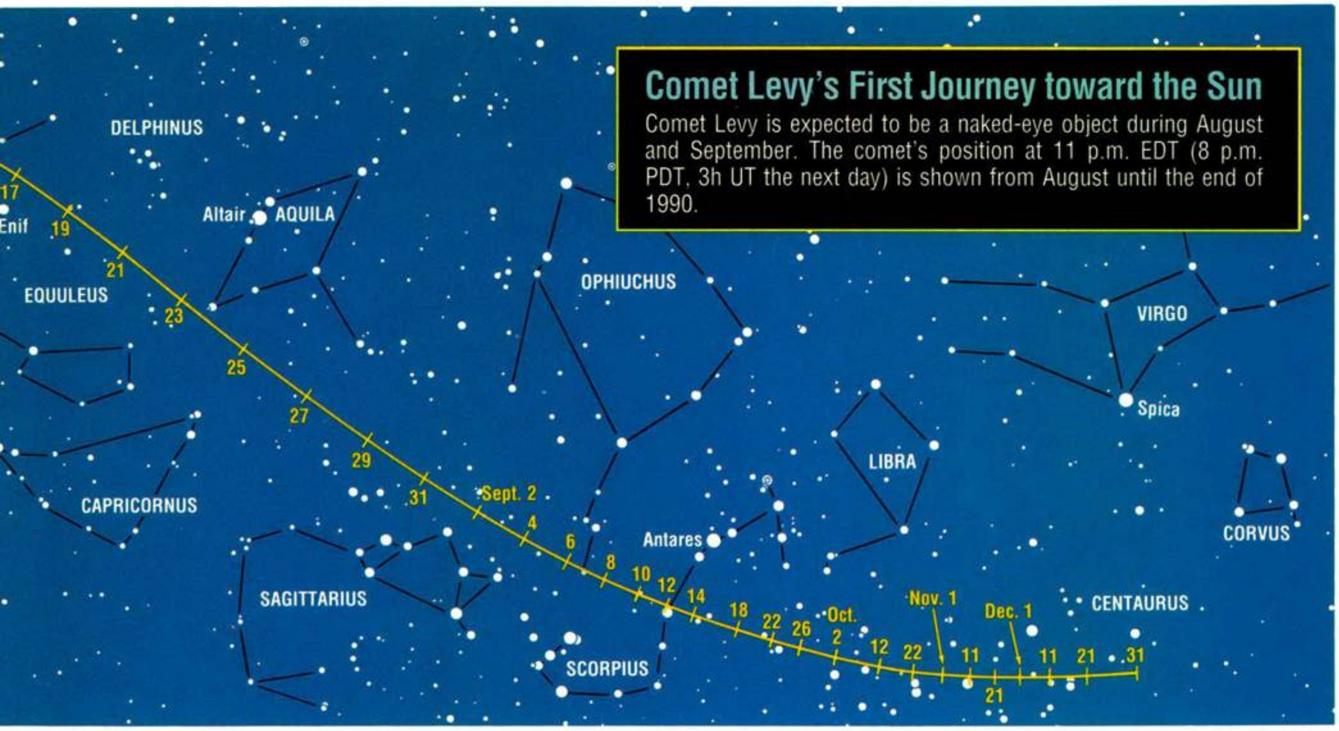
By New Moon on October 18, the comet is only 10° above the horizon in a dark sky. Observers will need an unobstructed horizon, perfect weather, luck, and observing skill to find the comet after this date. The 1990 apparition of Encke comes to a close as the comet is swallowed up by morning twilight.

A First-Time Visitor

The second comet to grace our sky this summer and fall is Comet Levy. Spotted by David H. Levy on the morning of May 20, 1990, it is the sixth comet discovered by the Arizona comet hunter. Unlike Comet Encke, which has a quick, two-month-long apparition in September and October, Comet Levy is already visible and will remain quite bright into 1991.

Unfortunately, because Comet Levy is making its first known appearance in the inner solar system, predicting how bright it will get and how it will look is much more difficult than with a well-observed periodic comet like Encke. Based on recent experience with Comet Austin, any brightness prediction for a new comet should be viewed skeptically. However, because Comet Levy is not going as close to the Sun as Comet Austin did, the uncertainty in the predictions is considerably less. Despite this, the estimates given below could be one or two magnitudes too faint or too bright.

At the time of its discovery, Comet Levy was a very slow-moving, 10th-magnitude diffuse patch of light near the star Alpha Andromedae. This slow motion meant that the comet was either quite far from Earth or moving almost directly toward (or away from) Earth. In fact, both were true. Early orbit calculations show that Comet Levy will continue to approach Earth until late August, when it will be about 40 million miles away. The separation will then increase as the



Comet Levy's First Journey toward the Sun

Comet Levy is expected to be a naked-eye object during August and September. The comet's position at 11 p.m. EDT (8 p.m. PDT, 3h UT the next day) is shown from August until the end of 1990.

comet approaches perihelion in October at a distance just inside Earth's orbit.

This orbital configuration produced a curious effect. For nearly two months after discovery, Comet Levy remained in the vicinity of Alpha Andromedae, and only after that did it begin to drift westward. By mid-August Comet Levy lies in Pegasus and should shine at about magnitude 4.6. Make sure to look for it on the night of August 18/19, when it passes about 1° from the globular cluster M15. On the next night the comet reaches opposition, when it is expected to glow at about magnitude 4.0 and will be visible in a Moonless sky for the entire night.

Picking up speed, Levy heads toward the southwest, cutting through Equuleus and Delphinus. At closest approach to Earth on August 25/26, the comet is moving over 4° a day against the stellar backdrop of southern Aquila. Your best view of the comet should come during the ten days leading up to closest approach. Levy is then at its brightest and is quite high in the sky for much of the night.

Unfortunately, the comet is unlikely to display a spectacular tail. Rather, it will probably appear as a moderately condensed fuzzball some 10 to 20 arcminutes in diameter. Little or no tail will be visible, because the comet never gets close enough to the Sun to generate a long tail and we are looking at the comet nearly head-on. The Moon begins to interfere in late August as the comet races toward the southwest, shrinks in size, and fades slowly.

During the first week of September, Comet Levy traverses the bright Milky Way in Sagittarius. The comet passes within a few degrees of several Messier objects during this time, though the nearly Full Moon lies nearby and interferes with the view. The two closest conjunctions based on early orbit calculations are those of the open cluster M25 on September 1 and of the Lagoon Nebula, M8, on September 4.

As the Moon leaves the evening sky after the first week of September, Comet Levy enters Scorpius. It slips out of view for Northern Hemisphere observers in the latter half of September, when it is in the constellation Lupus. However, Southern Hemisphere observers may not lose sight of it at all as it passes perihelion south of the Sun at brighter than 6th magnitude.

Like Comet Austin at discovery, Comet Levy appears to be an intrinsically bright comet. Is it really as promising as the initial brightness estimates suggest, or is it an Oort Cloud comet, like Comet Austin, that appears bright when it is far from the Sun only to fail to brighten as the coating of volatile ices on the nucleus dissipates? There is a hopeful sign. Comet Levy is well condensed; that is, it has a bright star-like condensation at the center of the coma. This indicates an active nucleus producing lots of dust. Comet Austin, even when it was close to the Sun, never showed this feature. Unfortunately, even if Comet Levy is an intrinsically bright comet, it is unlikely to become brilliant because its perihelion is not close enough to the Sun.

A Cometary Cavalcade

Two very dissimilar comets are now on their way to interesting apparitions in Earth's sky. Comet Encke's apparition will not be spectacular, but in the uncertain world of comets Encke is about as close to a sure thing as you can get. What makes this comet special is its rich history and the ongoing scientific research associated with it. To those of us who follow comets regularly, the return of Periodic Comet Encke is like a visit from an old friend — a visit that is eagerly awaited.

Comet Levy's performance, on the other hand, is less certain. Although it is not the overdue great comet that everyone is waiting for, it may stay within the range of backyard telescopes for a year or more. And as the new comet on the block, who knows what surprises it may hold? □

Charles S. Morris works at the Jet Propulsion Laboratory. He has observed over 120 comet apparitions, including those of Comet Encke in 1980 and 1984.

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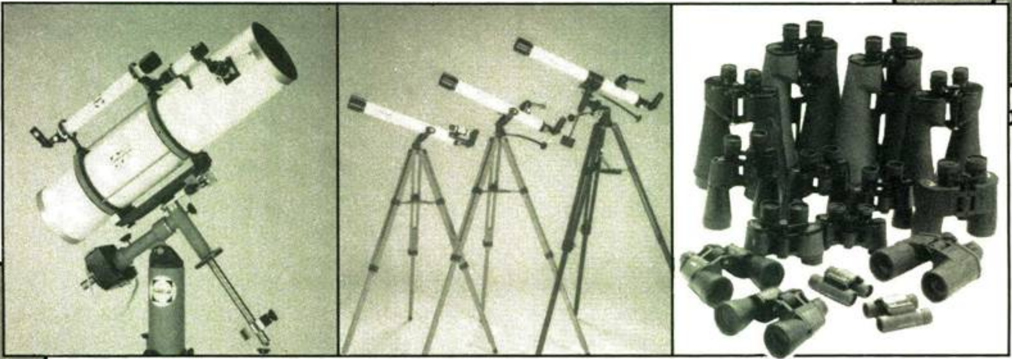

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The Changing Fortunes of Comet Austin

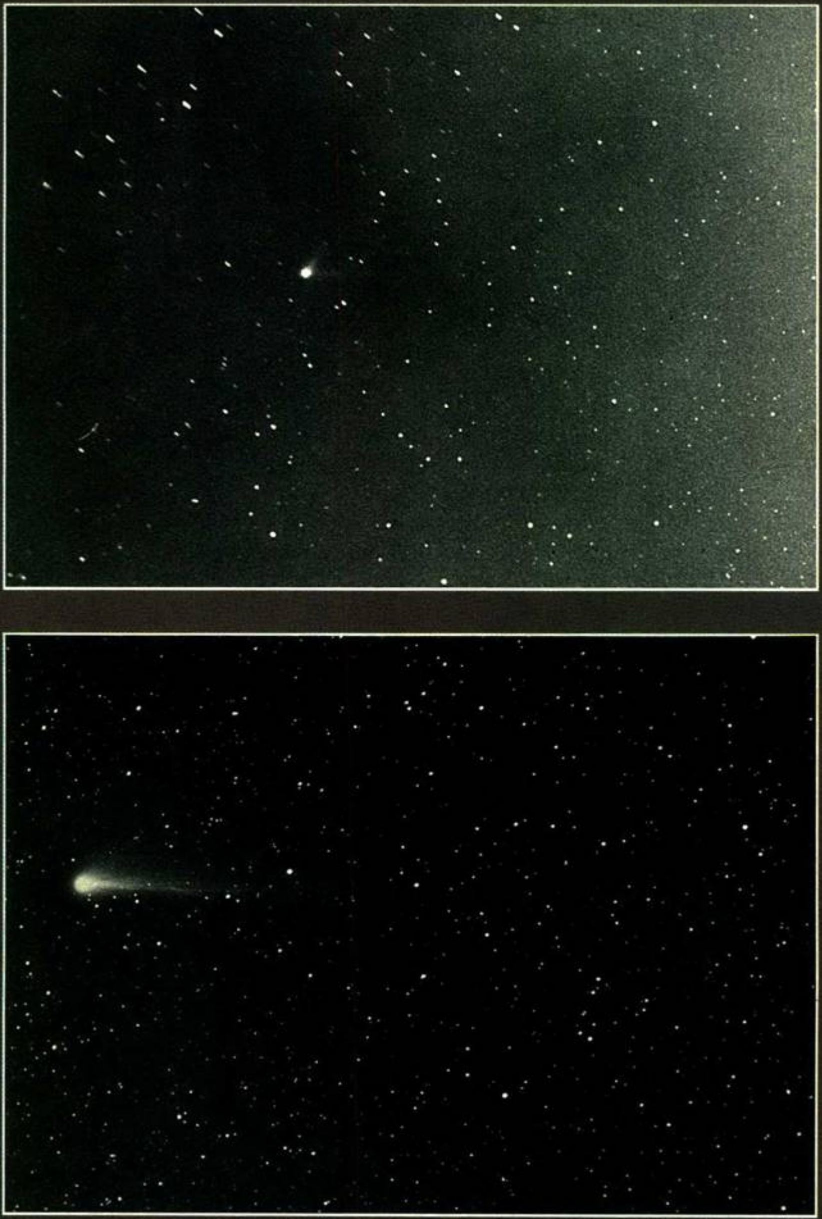
Although it did not become the comet of the decade,
Austin put on an impressive show for binocular and telescope observers.

by David J. Eicher

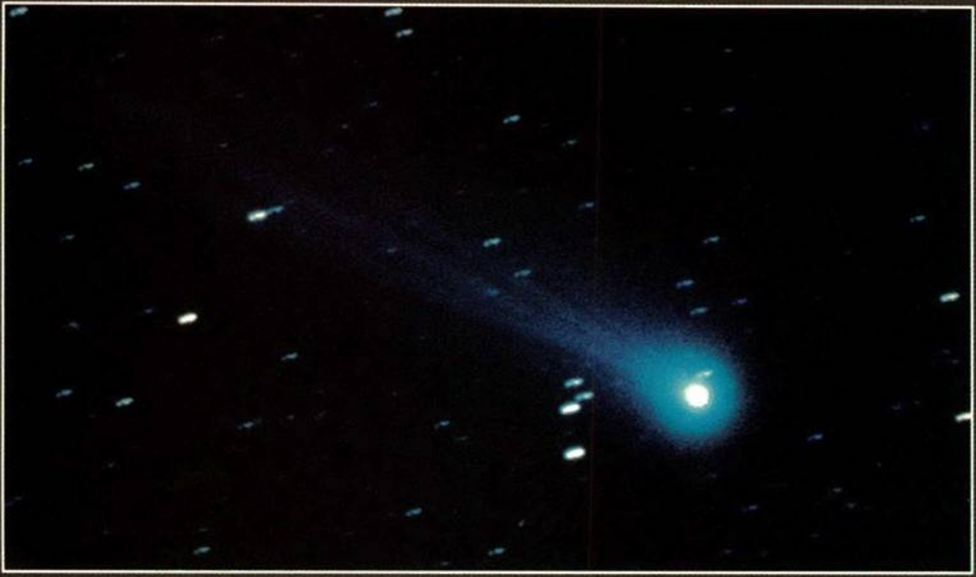
"Comet Austin will be the greatest since West, way back in 1975!" So read the headlines in December 1989, when New Zealand amateur Rodney Austin discovered an 11th-magnitude comet in the southern constellation Tucana. Several days later astronomers had precise positions showing the comet's motion and calculated an orbit suggesting that the new comet, designated 1989c_1, was on its way in and would brighten dramatically in April 1990. By mid-December 1989 the prognosis began to look good. Austin would shine brighter than 3rd magnitude on its perihelion date of April 9, and it would lie far from the Sun in the northeastern corner of Pisces.

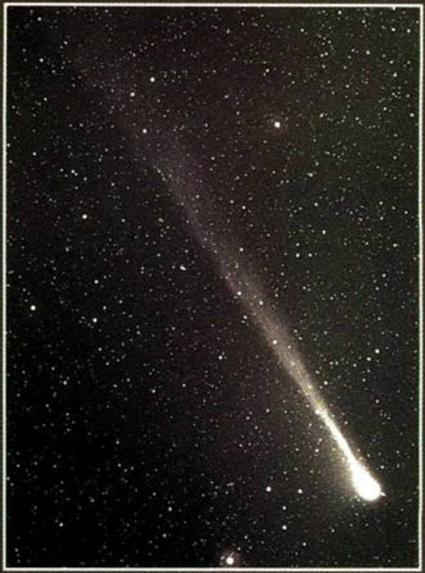
Comets have a way of behaving unpredictably, however. Comet Austin fell short of the predictions, but it still performed admirably. At its peak brightness in late April the comet shone at magnitude 4.8 and displayed a tail nearly 5° long in binoculars and stretching almost twice that distance on long-exposure photographs. During the last days of April the comet's tail developed a "streaky" structure, showing several sections. In May the tail virtually disappeared because of the comet's changing orientation, leaving a bright fuzzball reminiscent in shape of 1983's Comet IRAS-Araki-Alcock.

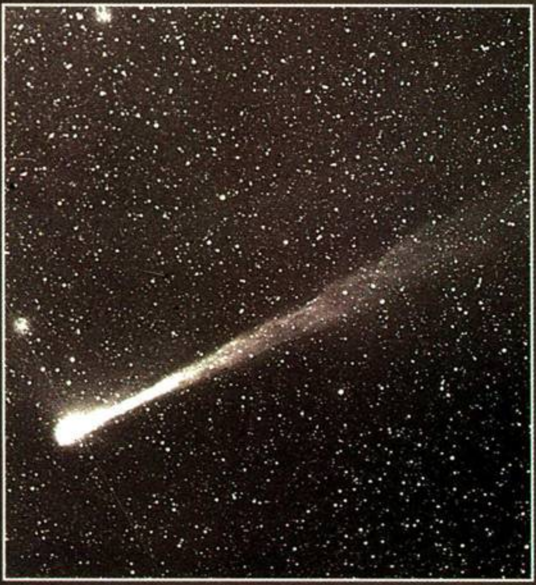
At the close of Comet Austin's apparition in late May, Arizona amateur David H. Levy discovered a 10th-magnitude comet near the star Alpha Andromedae. I had the opportunity to talk about Levy's comet with Brian Marsden, director of the International Astronomical Union's Central Bureau for Astronomical Telegrams, and an authority on cometary behavior. However, when asked whether Levy would really be spectacular, Marsden uttered just two words: "No comment." □



COMET AUSTIN BRIGHTENED to naked eye visibility during April 1990. The comet reached naked-eye visibility around March 19, when it glowed at 6th magnitude (top). By April 25, Comet Austin shone at magnitude 4.8, and observers with large binoculars saw a tail spanning 5° (bottom). Photos by Martin Hale.



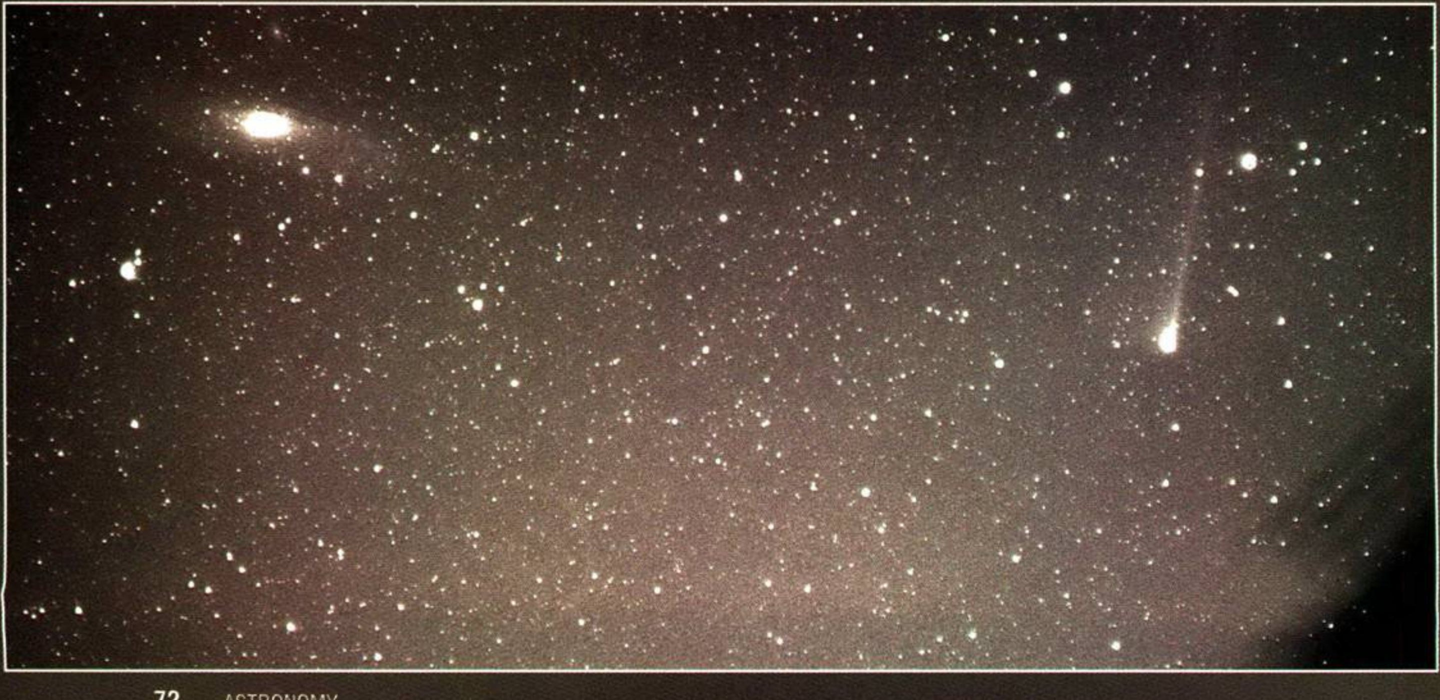


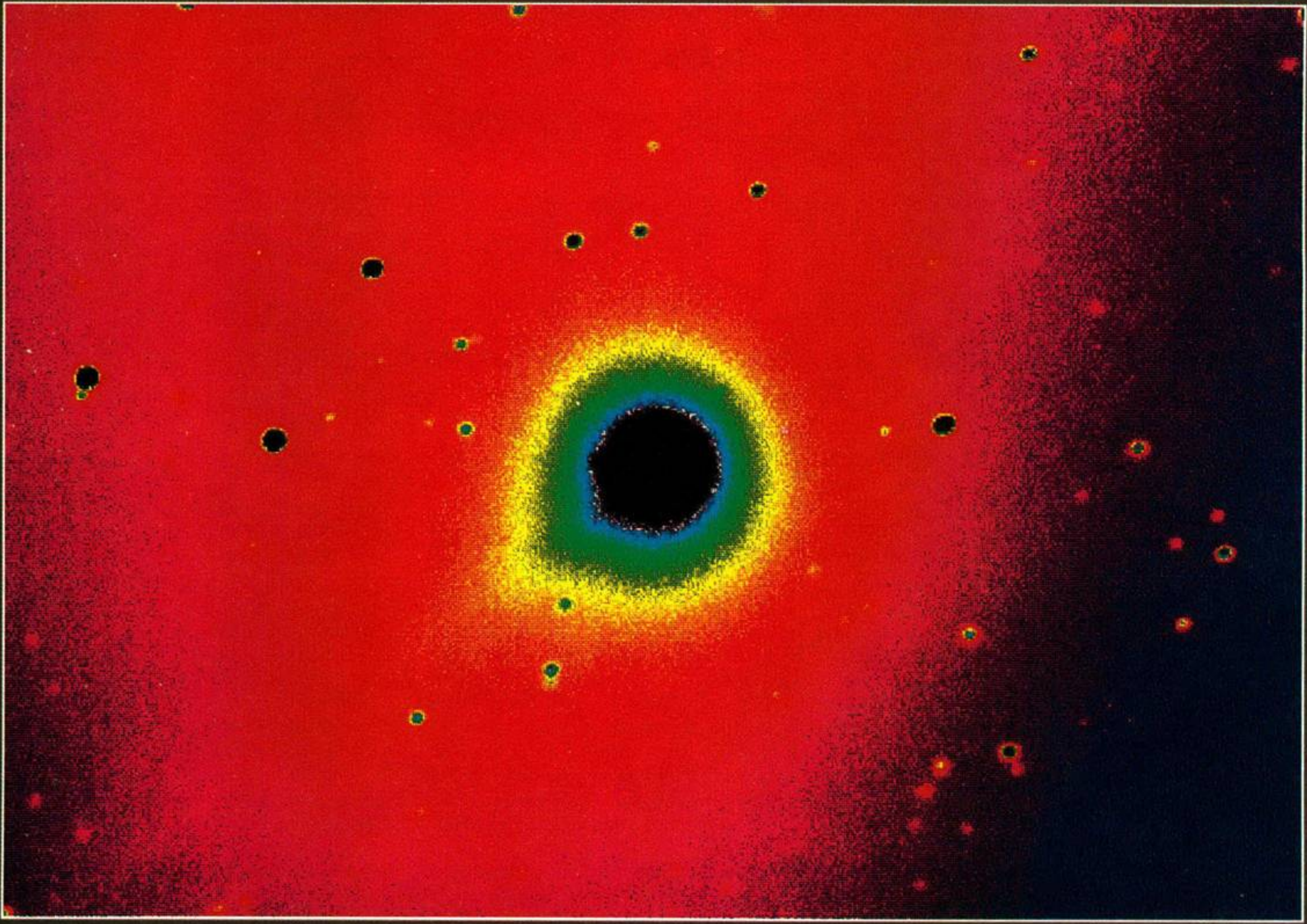


Comet Austin peaked in brightness as April slipped into May. Although the comet did not reach the brightness astronomers had originally predicted, it was bright enough to be observed with the naked eye. Binoculars showed a nucleus and coma that resembled 1983's Comet IRAS-Araki-Alcock, and telescopic photographs revealed a tail stretching nearly 8° in length.

During the last days of April the comet displayed a tail with several distinct, parallel components, as shown in Michael Stecker's photo from April 28 (above, left). A long exposure made one night later shows the same phenomenon (above, right). Photo by Chuck Vaughn. Early in the morning on April 29 Bob Yen captured a disconnection event, when a piece of the comet's tail (left) became detached. A wide-field photo made on April 28 shows Comet Austin as it passed by M31, the Andromeda Galaxy (below). Photo by Dennis Sørensen.

During May observers saw Austin's tail shrink to near invisibility, leaving a large, bright coma. On May 12 George E. Fowler captured an image of the comet using a 14-inch f/11 SCT and a STAR I CCD camera made by Photometrics, which he processed into a color-enhanced picture showing increasing levels of surface brightness (opposite page, top). John Stevenson's photo from May 6 shows Austin's blazingly bright coma sprouting a thin, sharply-defined tail (opposite page, bottom left). By May 20, almost no tail was visible as the comet began to fade to below 5th magnitude (opposite page, below right). Photo by Michael Stecker.





The Red Planet's Return to Glory

Observe Mars this year while it appears bigger and brighter than it will at any time during the rest of the twentieth century.

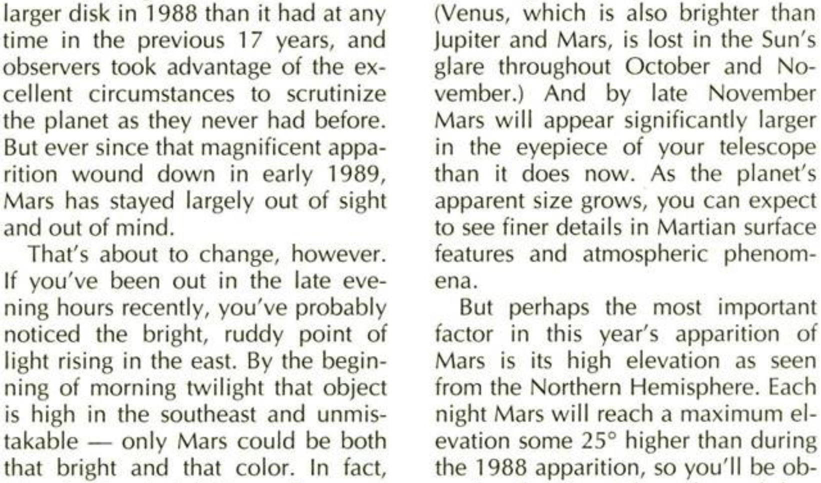
by Richard Talcott

Two years ago the eyes of backyard observers were glued to the planet Mars. The Red Planet shone brighter and presented a larger disk in 1988 than it had at any time in the previous 17 years, and observers took advantage of the excellent circumstances to scrutinize the planet as they never had before. But ever since that magnificent apparition wound down in early 1989, Mars has stayed largely out of sight and out of mind.

That's about to change, however. If you've been out in the late evening hours recently, you've probably noticed the bright, ruddy point of light rising in the east. By the beginning of morning twilight that object is high in the southeast and unmistakable — only Mars could be both that bright and that color. In fact, Mars is already brighter and appears larger in a telescope than at any time since 1988.

But this is only the beginning. Mars will continue to brighten between now and opposition in late November, when it will nearly match Jupiter as the second-brightest object in the nighttime sky after the Moon. (Venus, which is also brighter than Jupiter and Mars, is lost in the Sun's glare throughout October and November.) And by late November Mars will appear significantly larger in the eyepiece of your telescope than it does now. As the planet's apparent size grows, you can expect to see finer details in Martian surface features and atmospheric phenomena.

But perhaps the most important factor in this year's apparition of Mars is its high elevation as seen from the Northern Hemisphere. Each night Mars will reach a maximum elevation some 25° higher than during the 1988 apparition, so you'll be observing the planet through much less of Earth's turbulent atmosphere. No, the Red Planet won't be as bright or appear as large as it did in 1988, but the higher elevation this year will give you a steadier, sharper view of Mars, which partially offsets the planet's smaller size.



YOUR BEST VIEWS OF MARS will come during the two-month period around opposition when the planet appears larger than 15" in diameter. Nevertheless, you can still see a wealth of detail whenever Mars measures more than 10" across.

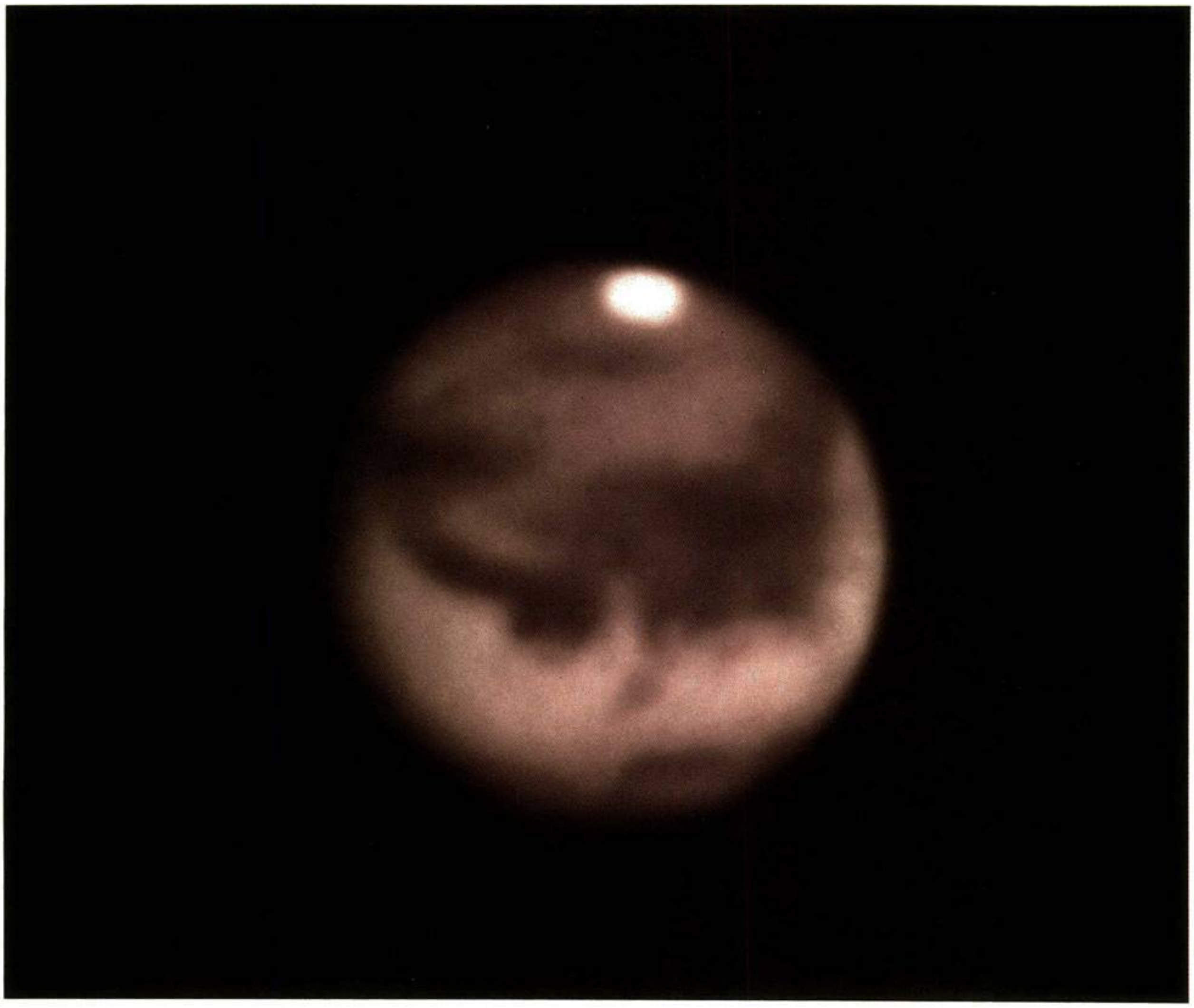
The Time Is Now

You can get a good view of Mars as early as mid-August. Through a 6-inch or larger telescope, many Martian surface features are visible when the planet's disk is 10" in diameter or larger. Photography of Mars is also worthwhile when the disk size exceeds 10". Although a good-quality 3-inch telescope also shows some features on a 10"-diameter disk, the view is substantially better once the disk size grows to 12". Twelve arcseconds is also the approximate size at which larger telescopes start revealing the fine surface detail and faint atmospheric phenomena that the Red Planet is famous for.

After growing larger very slowly through the first half of 1990, Mars finally reaches 10" in apparent diameter on August 16. It rises at about 11:30 p.m. local daylight time and shines at magnitude –0.2. You'll also notice a distinct phase effect in mid-August, as only 84 percent of the planet's sunlit hemisphere points toward Earth at that time. Mars will remain larger than 10" across for more than five months, falling below that benchmark on January 31, 1991.

The pace of change quickens as Mars approaches opposition. It grows to 12" in apparent diameter on September 13 and stays at least that large for four months, until January 14, 1991. And by October 13 the Red Planet is 15" in apparent diameter, a value it falls below again on December 23.

Mars appears largest when it makes its closest approach to Earth on November 20. On that day the planet measures 18.1" across, 0.2" larger than it does at opposition on the 27th when it is nearly 600,000 miles farther away. However, Mars is imperceptibly brighter at opposition



MARTIAN SURFACE DETAILS are much easier to see when Mars looms large in the sky, as it will this fall. Photo by Donald C. Parker.

than at closest approach because at opposition the planet's lit hemisphere directly faces us, while at closest approach there is still a slight phase effect. Your best views of Mars through a telescope will come during the last half of November when the planet appears largest.

After opposition Mars grows dimmer and appears progressively smaller in the eyepiece, though you will still be able to see a lot of detail into 1991. Paradoxically, naked-eye observers and the general public will probably be more aware of Mars after opposition. That's because it is above the horizon and very prominent as the sky grows dark in the evening.

The Right Equipment

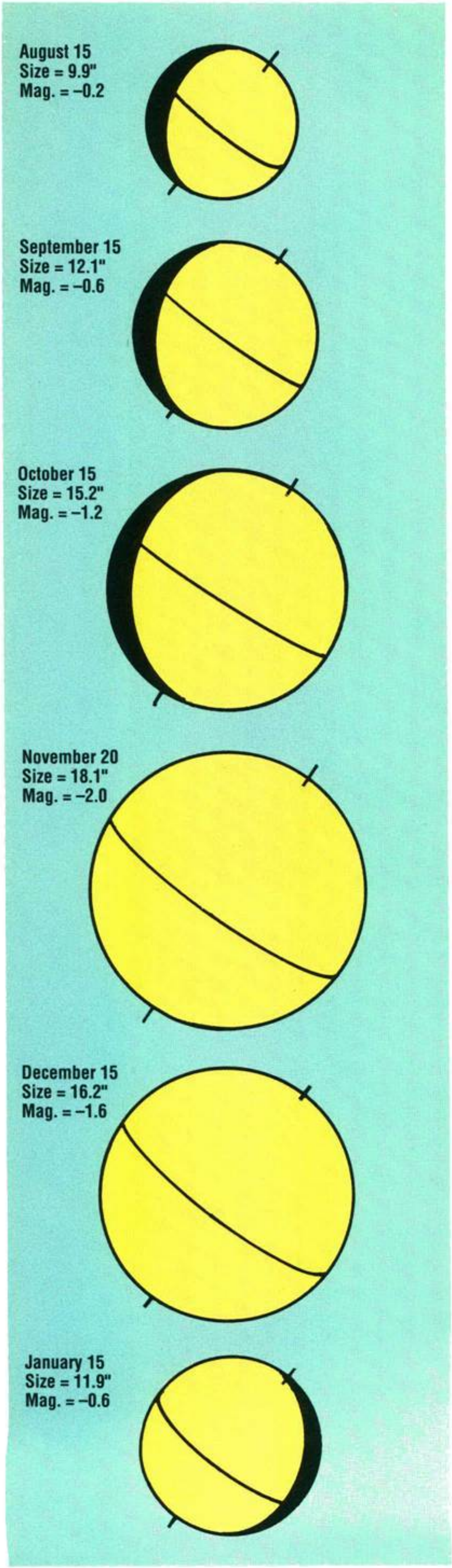
To get a good, sharp view of Mars during this apparition, you'll want to use at least a well-made 3-inch refractor or 6-inch reflector. A larger telescope will show more detail for a given Martian disk diameter and give you a longer time span to observe the apparition because you'll be able to see details when the disk is smaller. Your scope also needs to be well collimated and must have clean optics to deliver high-contrast views.

Good seeing conditions are also necessary to get the sharpest views of the Martian disk. Try to observe Mars when it is reasonably high in the sky so you don't have to look through as much atmosphere. Also, give your telescope 30 to 60 minutes to cool down to the ambient air temperature before observing, especially on cold nights in late autumn and winter.

High-quality eyepieces are another must for observing Mars. Plössls and orthoscopics are excellent because they provide good color correction and eye relief. Once you've found Mars in a low-power eyepiece, increase the magnification to roughly 20 to 25 times the telescope's aperture in inches (e.g. 160x for an 8-inch telescope). If conditions are good, this should give you a crisp view with enough magnification to see quite a bit of detail. Then try successively higher-power eyepieces until increasing the magnification shows you no more detail. Back off to the previous eyepiece and you should have an aesthetically pleasing view with as much detail visible as your scope and the night's conditions allow.

You'll also find a set of color filters helpful. Filters work by transmitting light of one color and absorbing light of complementary colors. This increases contrast between areas of different color, highlighting some features and de-emphasizing others.

Filters are especially useful on telescopes over 6 inches in aperture and can be a virtual necessity on scopes larger than 12 inches clear aperture, which otherwise can give such a bright image that contrast seems reduced. The amount of light absorbed by a filter can create a problem for smaller telescopes, however, because cutting out too much light



MARS SWELLS RAPIDLY in apparent size between now and November 20, when it will be closer to Earth and thus appear larger than at any time in the next decade. After closest approach Mars' apparent diameter shrinks even more rapidly. South is at top in these diagrams to match the view in a telescope.

leaves the image hopelessly dim. Particularly for small-scope owners, it's best to start with one or two filters — a red and a blue filter are good choices — before buying a complete set.

You can buy gelatin filters at most camera stores. These filters are relatively cheap, but they are soft, and it can be difficult to remove smudges and fingerprints without damaging them. The more expensive glass filters are available through some optical dealers and photo supply stores and through many of the companies that advertise in ASTRONOMY.

For observing Martian surface features, yellow, orange, and red filters work best. Yellow filters (Wratten 8, 12, or 15) brighten Martian desert regions while suppressing green and brown features. Orange filters (Wratten 21 or 23A) increase contrast between light and dark features and accentuate dust clouds. Red filters (Wratten 25 or 29) are probably the most useful for observing details because they provide the greatest contrast for Martian surface features.

Green, blue-green, blue, and violet filters, on the other hand, are better for seeing atmospheric phenomena. Green filters (Wratten 56, 57, or 58) are excellent for revealing ground fog and frost. Blue-green filters (Wratten 64) show ice fogs and haze in the polar regions. Blue filters (Wratten 80A, 38, or 38A) emphasize mid-altitude clouds and limb hazes. And violet filters (Wratten 47) are useful for showing high-altitude clouds, the polar cap hoods, and limb hazes.

A complete set of filters will include all the ones mentioned above plus a magenta filter (Wratten 30 or 32), which heightens details in the polar regions. Although filters are not a necessity for casual Mars observing, experienced Mars observers swear by them and the improved views they provide.

The Polar Caps

No other features on Mars stand out like the polar caps. These bright white aggregates of water ice and frozen carbon dioxide are easy to see whenever they are facing Earth, even when the Martian disk is quite small. And they are fun to watch as they wax and wane with the planet's changing seasons.

The major factor that determines the extent of the Martian polar caps is the season in each hemisphere. Mars' axis tilts 25° to the plane of its orbit around the Sun, just 2° more than the tilt of Earth's axis. This causes seasons on Mars that are similar to those we experience on Earth, but which also differ in two significant ways. First, each Martian season lasts nearly twice as long as those on Earth, which reflects the fact that the Martian year equals almost two Earth years. Second, seasons in the southern hemisphere are more severe than those in the north, because Mars is always closer to the Sun when it is summer in the southern hemisphere and farther from the Sun when it is winter in the southern hemisphere.

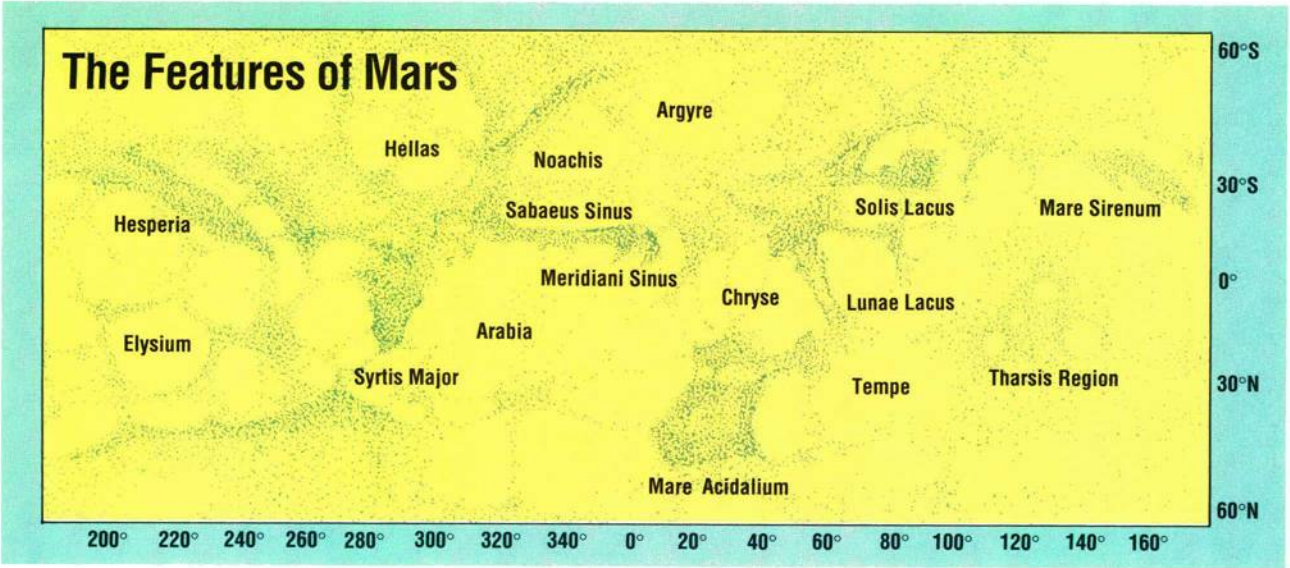
Summer began in the southern hemisphere of Mars on July 30. The Sun's rays are now beating down on the south polar cap, causing the ice to sublimate (turn from a solid directly into gas). In your telescope's eyepiece you'll be able to see the south polar cap shrink as the apparition progresses.

The south cap will appear most prominent early in the apparition, when the cap is relatively large and the southern hemisphere is tilted more strongly toward Earth. By the time of opposition in late November the cap will have shrunk considerably. Because we'll then be looking straight down on the equatorial regions, the cap should appear as a tiny white spot on the planet's south limb.

The north polar cap, on the other hand, will be growing through the end of the year. Winter begins in the northern hemisphere of Mars on the same day summer begins in the south, July 30, and the north polar region experiences constant cold and darkness. You won't see the cap early in the apparition: there's no sunlight to illuminate it, and even if there were, the cap is tilted away from us. But by the time closest approach occurs in November the geometry is more favorable and sunlight reaches within 10° of the pole, so you may well catch a glimpse of the brilliant north polar cap. If not, you may still spot the north polar hood, a bluish white haze in the Martian atmosphere that often hides the cap itself.

Martian Clouds

The polar hood isn't the only atmospheric activity you're likely to see, however. The Martian atmosphere is surprisingly dynamic con-



The Features of Mars

sidering that its density is just 1 percent of Earth's. A wide variety of hazes, clouds, fogs, and frosts occur on Mars and can be spotted in backyard telescopes, particularly if you use the green, blue-green, blue, and violet filters listed above.

Perhaps the most interesting clouds are orographic clouds, which form when moist air cools as it rises over high mountains. Orographic clouds appear white and are composed of water-ice crystals. They are most common around the huge volcanos of the Tharsis Region — Olympus Mons, Ascraeus Mons, Pavonis Mons, and Arsia Mons. The volcanos themselves are extraordinarily difficult to see when Mars appears less than 20" in diameter, as it does throughout this apparition, but spotting these orographic clouds at least gives you a way to detect the presence of the volcanos by seeing their effect on Martian weather.

The most dramatic weather phenomenon you might see on Mars are dust storms. No one knows when a dust storm will hit or how severe it will be, but the worst of these storms can obliterate the entire planet under a blanket of yellow dust. Dust storms usually occur following Mars' perihelion, which occurs this year on June 30, so keep a lookout for developing storms over the next few months. You can usually spot them as an unusual brightening that encroaches on neighboring dark features. Keep a particularly close eye on the Hellas Basin, the Serpentis-Noachis region northwest of Hellas, and the Solis Lacus region, where many previous dust storms originated.

To be able to spot the changing features of Mars — the clouds, frost patterns, incipient dust storms, and the like — you need to know the features that don't change or that change only slowly. The map above shows those features within approximately 60° latitude of the Martian equator. Learn these dark, static features and use them as a guide to locate the changing features in the months ahead.

With the table at right, you can determine the central meridian of Mars — the line of longitude that bisects the visible hemisphere — at any time on any night during the best observing period. But because Mars rotates continuously, once every 24 hours, 37 minutes, and 23 seconds, you'll need to do some simple calculations if you plan to observe at a time or on a date not specifically listed. Once you know the central meridian at the time of your planned observation, use the adjacent map to find which features are visible.

The ever-changing appearance of Mars is a drama that is fascinating to behold. You can enjoy Mars just by following it with your naked eye or by occasionally viewing it through a telescope. But you can also get heavily involved in systematic observations of Mars, and by so doing help astronomers learn more about our neighbor. The Association of Lunar and Planetary Observers collects and compiles observations made by amateur astronomers. If this kind of dedicated observing program is of interest to you, write for more information to ALPO Mars Recorders, Box 97-0469, Miami, FL 33197-0469.

When the current apparition winds down in early 1991, Mars observers will be left with bittersweet feelings. They'll be happy about the past apparition, but frustrated about the future. Mars' next opposition doesn't occur until January 1993, and that one is rather poor. And the three apparitions following that are even worse.

Martian Central Meridians

Date	Central Meridian
October 13	263°
October 18	217°
October 23	172°
October 28	126°
November 2	82°
November 7	37°
November 12	353°
November 17	309°
November 22	265°
November 27	221°
December 2	177°
December 7	133°
December 12	88°
December 17	44°
December 22	359°

Use this table to determine the meridian at the center of Mars' disk at any time and then refer to the map above to see what surface features are visible. The central meridian is shown for 11 p.m. EST during the best observing period. To find the central meridian for other dates and times, subtract 9.1° for each day after a tabulated date and add 14.6° for each hour after the tabulated time.

Not until 2001 is Mars as close as it is this year, and in that year Mars will be far south and appear very low in the sky from mid-northern latitudes. It will be thirteen years from now before Mars has as favorable an apparition for Northern Hemisphere ob-servers as it does this year. And that one will be the equal of the great apparition of 1988. But thirteen years is a long time to wait. Don't miss the opportunity to observe marvelous Mars while you have the chance this year. □

Splashy Summer Star Clusters

Ready to give up on naked-eye observing? Discover four dazzling open star clusters visible to the eye alone and grand sights in binoculars.

by Alan Goldstein

The summer sky contains many beautiful open clusters. These collections of stars consist of anywhere from several dozen to several thousand members scattered loosely over volumes of space from less than twenty to more than two hundred light-years in diameter. Although they lie at great distances, the largest and brightest open clusters still appear large in our sky because of their great physical sizes. The closest of these open star clusters are bright enough to detect with the eye alone under a dark sky.

Open clusters vary widely in appearance. Some are quite dense, resembling miniature globular clusters. Others are so poor they almost blend in with the background star field. Their current appearances depend largely on their ages: Formed from gas and dust, the newly born stars in clusters slowly move apart and dissipate as they orbit the center of the Galaxy.

One of the brightest summer clusters is **M7** (NGC 6475) located in the tail of Scorpius. Although the brightest members of M7 glow at about 6th magnitude, the integrated magnitude of the entire cluster is 3.3, making it a naked-eye object even under mildly light-polluted skies. Under dark rural skies, M7 and its neighbor M6 look like two bright knots in the southern Milky Way.

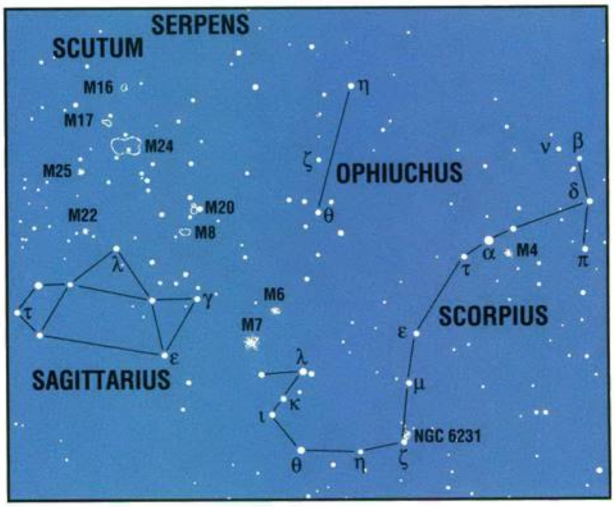
In binoculars and small telescopes, the brightest members of M7 resemble a letter "K" turned on its side. Slightly more than 1° across, M7 is best observed with binoculars or an RFT. In fact, any view less than 2° in diameter diminishes this cluster's spectacular appearance. Because half of its 130 members are brighter than 10th magnitude, M7 is a good subject to impress your non-astronomer neighbors or family members even under suburban skies.

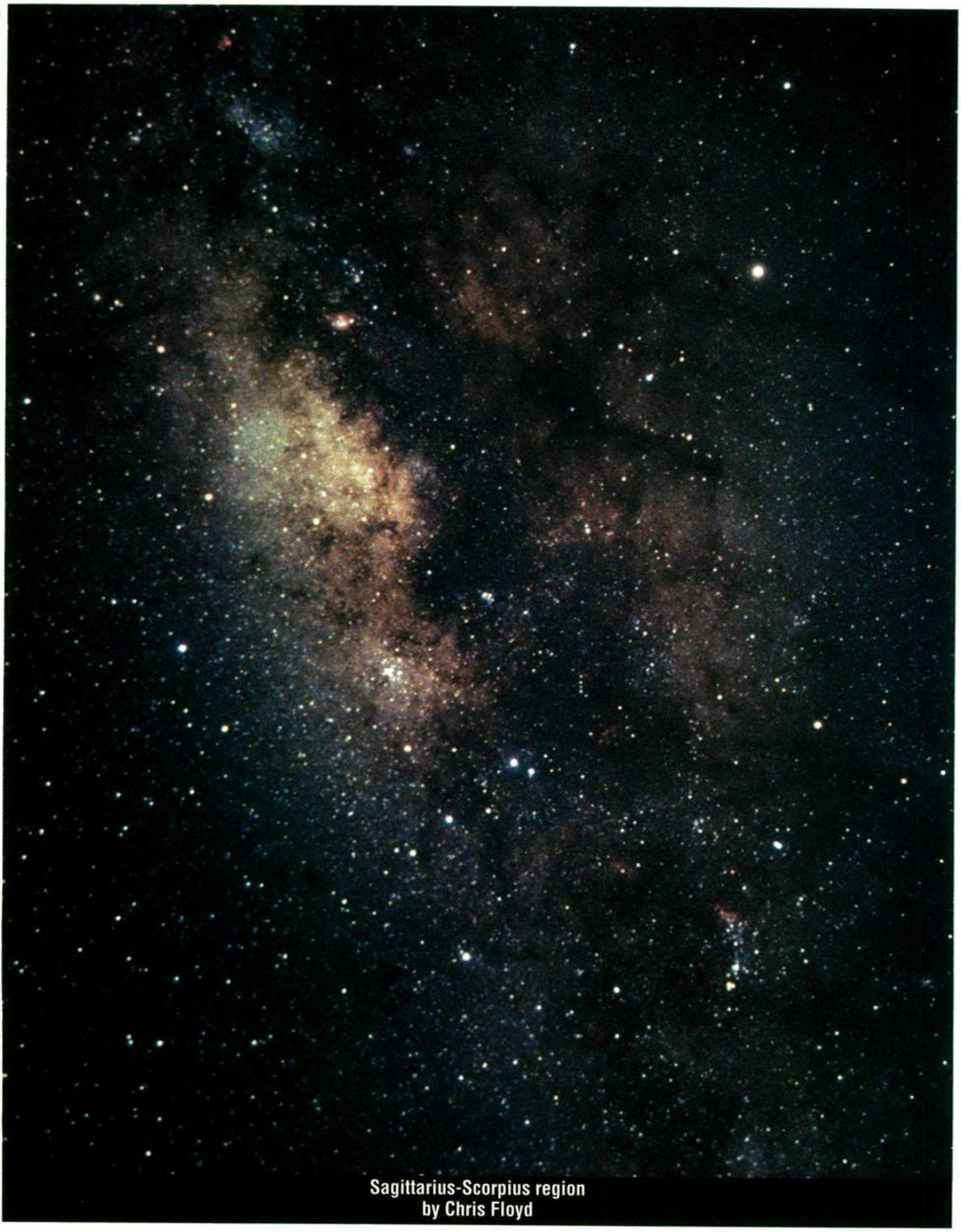
M7 lies in front of a mottled Milky Way star field full of bright patches and ribbon-like dark nebulae. Can you see them? A wide-field telescope or large binoculars should do the trick under very dark skies. A field diameter between 3° and 5° is required. The bright stars in M7 will actually interfere with your ability to pick up the subtleties in background glow. Another challenge is finding the tiny globular cluster NGC 6453, which is located on the western edge of M7 although actually it is considerably farther away from us.

About 3.5° northwest of M7 lies **M6** (NGC 6405). Visible to the naked eye as a magnitude 4.2 glow, this is another splashy cluster in the summer sky. Many observers see the brighter stars of this 130-member cluster as forming the shape of a butterfly wing. It is therefore not surprising that this cluster is often called the Butterfly Cluster. On nights of mediocre seeing, the butterfly pattern may not be obvious and the brighter stars form a "W"-shaped pattern. Looking closely at the fainter stars at the southern end of the cluster should make the W-pattern more apparent.

The brightest stellar member of M6 is **BM Scorpii**.

M7
Mag. 3.3 Size 80' by Alfred Lilge

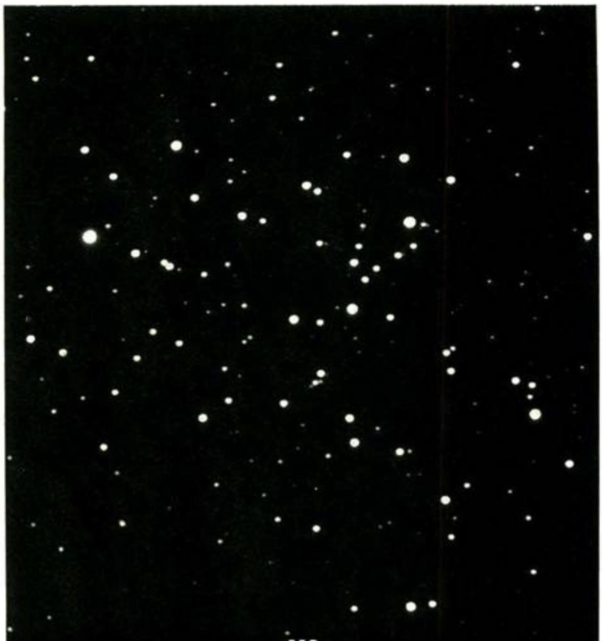




Sagittarius-Scorpius region
by Chris Floyd

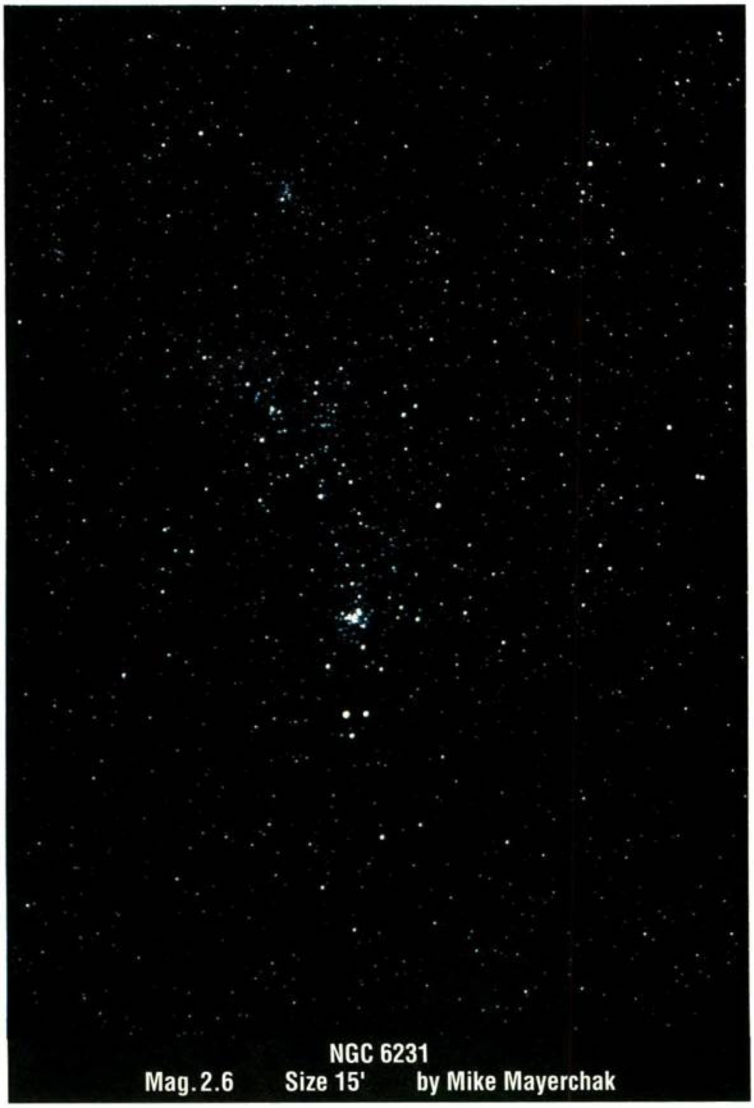
It is an irregular variable, orange in color (spectral type K0 to K3), with a period of roughly 850 days. Catch it at its brightest and it stands out at magnitude 6.0. If you spy it at minimum brightness (8.1 magnitude), BM Sco will still be conspicuous and very red. If you have ever thought about dabbling in variable star observing, following BM Sco's semi-unpredictable pattern of variation makes a good project.

Although **M25** (IC 4725) is a spectacular cluster in Sagittarius, it is not as richly packed with stars as M6 or M7. This cluster contains over fifty members approximately 6th magnitude and fainter. Its total magnitude is 4.6, making it a naked-eye object under a dark sky. M25 is a showpiece for binoculars and rich field telescopes. The 32' diameter cluster accents an already rich star cloud toward the center of our galaxy. The brightest members of this cluster glow with a variety of colors that can be observed in binoculars or a



M6
Mag. 4.2 Size 15' by Ben Mayer

M25
Mag. 4.6 Size 32' by Lee C. Coombs



NGC 6231
Mag. 2.6 Size 15' by Mike Mayerchak

Summer Naked-Eye Clusters

Object	R.A. (2000.0) Dec.	Mag.	Size
NGC 6231	16h54.0m -41°48'	2.6	15'
M6	17h40.1m -32°13'	4.2	15'
M7	17h53.9m -34°49'	3.3	80'
M25	18h31.6m -19°15'	4.6	32'

Object: Designation in Messier or NGC catalog. **R.A. and Dec.:** Right ascension and declination in equinox 2000.0. **Mag.:** V magnitude. **Size:** Diameter in arcminutes.

low-power telescope. In larger telescopes, color tends to become muted and more difficult to see because of the intensity of starlight.

NGC 6231 would be one of the all-time favorite open clusters if it was not located so far south. If your latitude lets you observe the southern reaches of Scorpius, this is a "must-see" star cluster. NGC 6231 contains about 120 stars and is very striking because of the preponderance of bright blue-white members. NGC 6231's brilliant members together shine at magnitude 2.6, making it rather impressive even if it lies relatively near the horizon. From anywhere south of +40° latitude this cluster is an easy and spectacular naked-eye object.

Spend a few nights gazing up at these spectacular summer clusters. Whether you observe these star groups with the naked eye, binoculars, or a small telescope, you'll see that they represent some of the prettiest sights in the summer sky. ☐

Alan Goldstein is the founder of the National Deep Sky Observers Society, a contributing editor of Deep Sky *magazine, and one of the authors of the book* Deep Sky Observing with Small Telescopes *(Enslow, 1989).*

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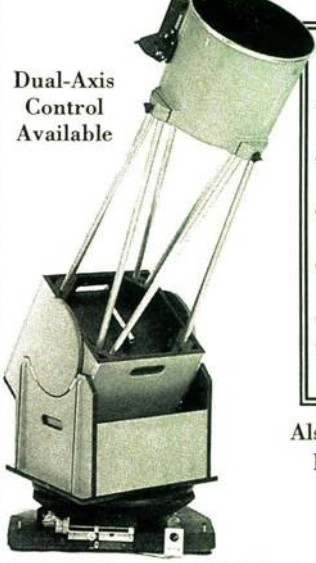

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Illum EP 419	96	T-adapt-vari	49
LED map light	29	T-mt.-non AF	14
Lenshood 8"	59	T-mt.-AF	19
Lenshood 10"	89	Vari pol 905	45
Nebula 1.25"	69	Weight set 8"	84
Nebula 2"	129	Weight set 10"	89
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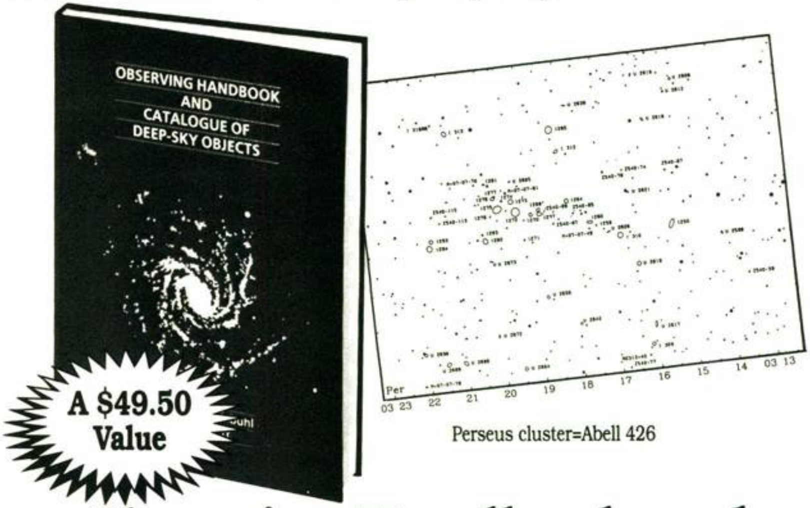

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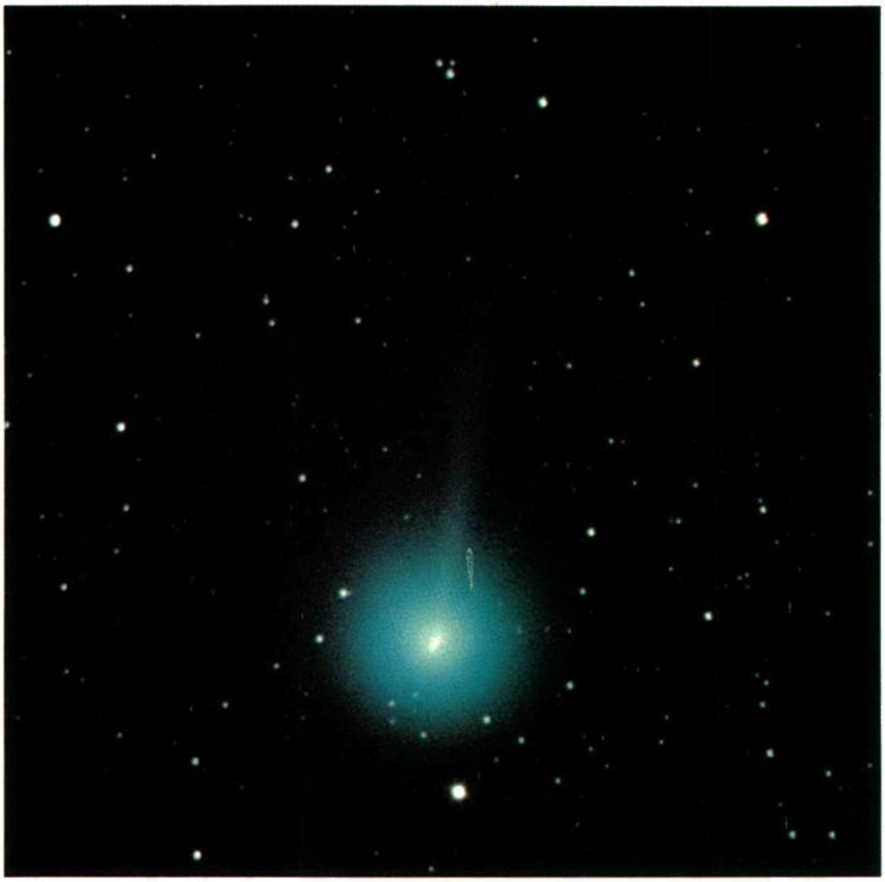
AMATEURS OBSERVE COMET AUSTIN

Comet Austin (1989c_1) put on a good show throughout April and May 1990. Comet Austin shone brighter than 5th magnitude and developed a tail spanning nearly 10°. (See "The Changing Fortunes of Comet Austin," page 70.) Some observers were disappointed because early predictions suggested that Austin would be much brighter, and a really bright comet is statistically long overdue. However, most observers were quite happy with the apparition of Austin; many wrote to us about their observing experiences and sent the photographs that appear here.

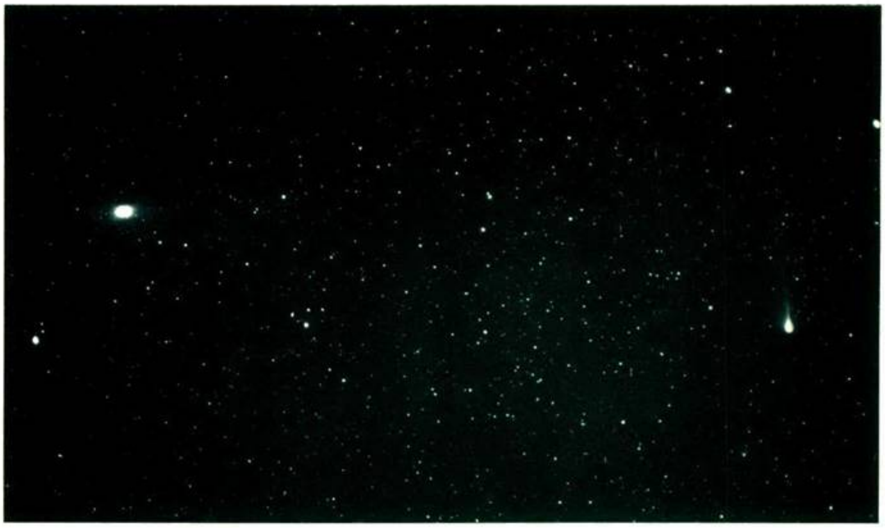
From Horsens, Denmark, Dennis Sørensen reported that during the last week of April the comet was "an easy object in my 10x50 binoculars with a tail that can be followed out visually to 4° in length." On April 30, California observer Ronald E. Royer reported that the comet was "barely a naked-eye object even though I knew exactly where to look. I estimated its brightness at 5th magnitude and observed about 1° of tail in binoculars." From Payson, Arizona, astrophotographer Chris Schur observed the comet on April 29 and reported that "visually the comet's tail measures 3° in length in a telescope, but photographically the tail stretches more than 9°. The dust portion of the tail is minimal if not nonexistent."

During May, Ron Peters of Saskatoon, Saskatchewan, monitored the comet's gradual fading as the month progressed. He recorded magnitudes of 5.8 (May 5), 5.9 (May 9), 6.0 (May 17), 6.1 (May 25), 6.3 (May 27), and 6.5 (May 29). Peters' numbers indicate that by the end of May the comet was nearly below the threshold of naked-eye visibility, even from a very dark site.

"I've been following Austin nearly every clear morning during May," writes George W. Gliba of Greenbelt, Maryland. "The only time I saw an appreciable tail was during early May. On May 5 the comet glowed at magnitude 4.5 and had a fan-shaped tail measuring 1.5° in length. I watched the comet fade as it traversed Andromeda, Delphinus, Aquila, and finally Sagittarius. On May 31 I saw Comet Austin and the Omega Nebula (M17) together in the same low-power field. They were framed nicely less than 1° apart in a field laden with faint stars. You couldn't have chosen a prettier way to end a comet's apparition!"



ALL COMA, NO TAIL summarizes Comet Austin's appearance in May 1990. The comet remained visible to the naked eye throughout May. Photo by Chris Schur.



AUSTIN AND M31 paired in the morning sky on April 27, when the comet brushed within 5° of the great galaxy. Photo by Ken Burgess and Chris Schur.

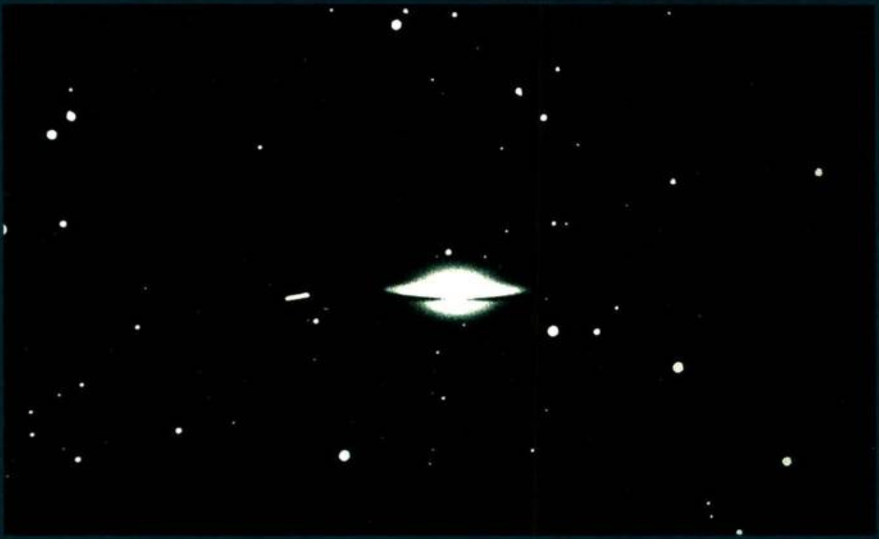
SKIMMED BY AN ASTEROID

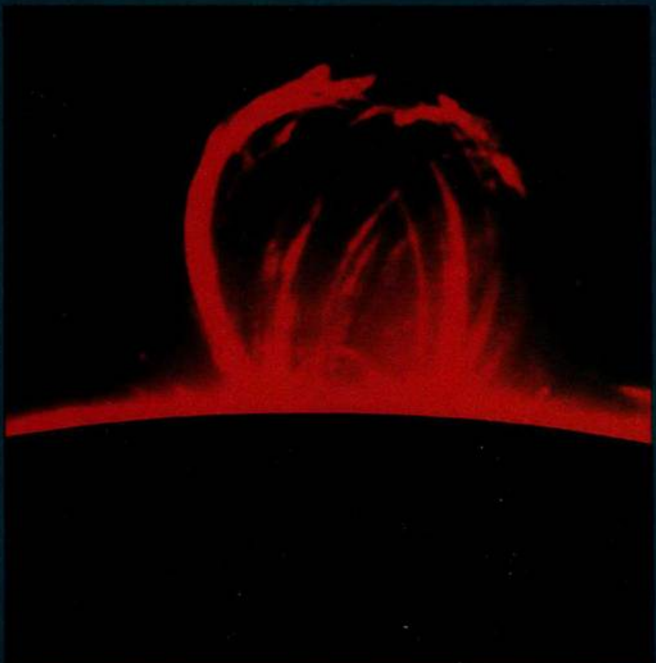
Only rarely do cosmic close calls occur like the one on the evening of April 27, 1990. At that time the asteroid 35 Leukothea skimmed the northern edge of M104, the Sombrero Galaxy in Virgo. The 12th-magnitude asteroid was captured during its closest encounter with M104 by Marco Antonio De Bellis of Rio de Janeiro, Brazil. De Bellis' photo (right) wins this month's $100 "Best Astrophoto" a-ward. To capture the asteroid's motion, De Bellis used an 8-inch f/10 SCT, hypersensitized Tech Pan film, and a 90-minute exposure. Several hours earlier Jeffrey Jones of Tracy, California, captured the asteroid as it approached M104 (below). Jones used an 8-inch f/10 SCT, hypered Tech Pan, and a 110-minute exposure.

The asteroid's close approach to M104 wasn't the only such recent encounter. Last spring Paula Drake of Houston, Texas, caught a bright meteor as it unexpectedly zipped past NGC 6992-5, the Veil Nebula in Cygnus (bottom left). Drake used a 12.5-inch f/5 reflector, Konica 3200 film, and a 30-minute exposure.

Particularly fine nebular detail was captured by Tony Hallas and Daphne Mount in their photograph of dark globules associated with the emission nebula IC 1396 in Cepheus (opposite page, bottom). Hallas and Mount used a 6-inch EDF refractor and hypered Tech Pan film for the photo.

Jean Dragesco's remarkable composite photo shows a huge loop prominence on the Sun (bottom right). Dragesco used a 14-inch f/11 SCT and a Daystar hydrogen-alpha filter for the photograph.

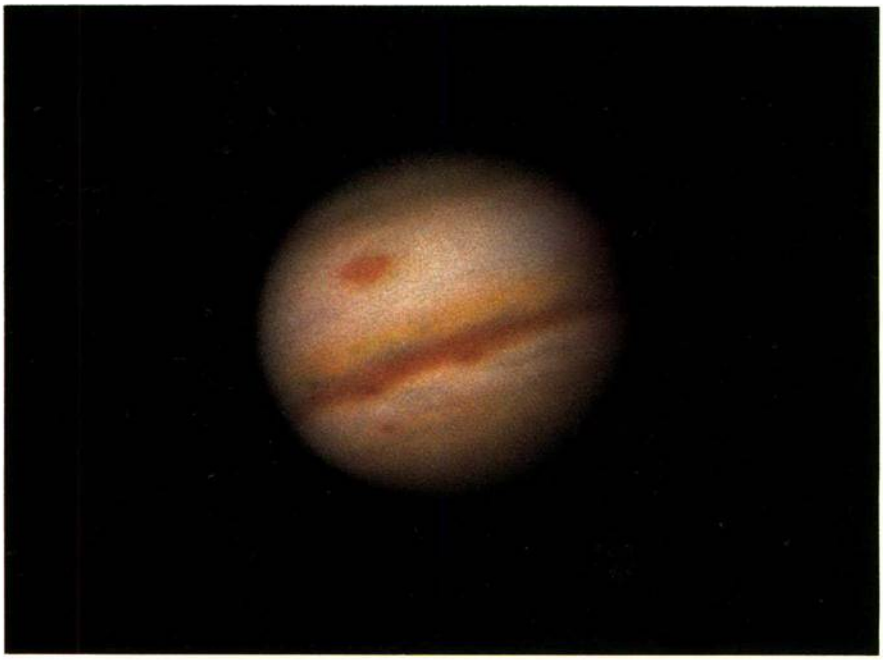




JOVIAN ACTIVITY ABOUNDS

Planetary observers continue to report unusual activity on Jupiter. The planet has been very active since last year, when Jupiter's normally dark and prominent South Equatorial Belt brightened into invisibility against the planet's bright disk. Fred W. Price, a professor of biology at Buffalo State College in New York and an active sketcher of Jupiter, observed dark cloud features in late December 1989. Price used an 8-inch reflector at 225x. "My drawings of December 14, 1989, and February 1, 1990, show traces of the virtually invisible South Equatorial Belt," reported Price.

"The Great Red Spot was easily visible," Price continued, "appearing subtle pink-orange in color and surrounded by bright zonal material. The north edge of the North Equatorial Belt appeared to have thick, dark linear condensations spaced at intervals along its long dimension. These condensations are quite distinct from the short, thin



RICH YELLOW, BROWN, AND ORANGE highlight the pale cloudtops of Jupiter in this photo taken last April with Fuji Super HG 400 film. Photo by Tony Hallas and Daphne Mount.

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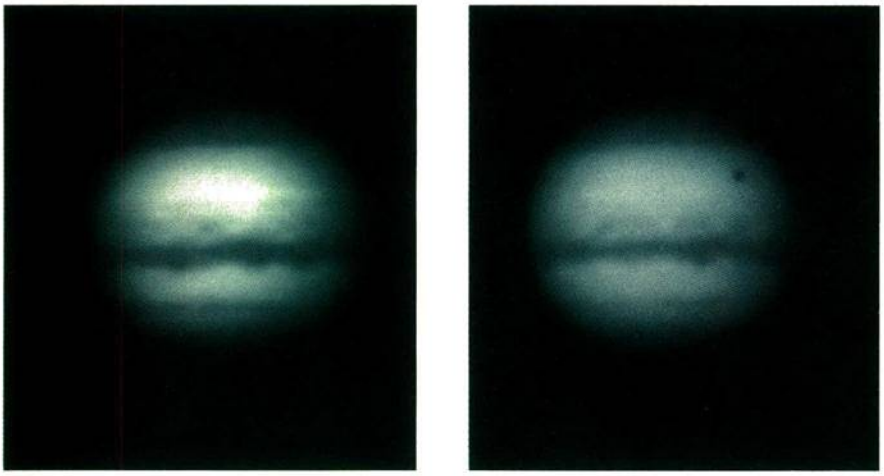

WAVY BELT DETAILS highlighted Jupiter's appearance last January (left). During the first week of February, a major festoon extended away from the planet's North Equatorial Belt (right). Photos by Gregory Terrance.

'rafts' that often appear in the North Tropical Zone adjacent to the North Temperate Belt. The planet's equatorial region seems to have a yellowish tinge that shows distinctly on recent color photos I've seen."

Dan Boyar, an observer living in Boynton Beach, Florida, observes Jupiter with a 10-inch f/6.5 reflector at magnifications of 138x to 245x. "I enjoy drawing Jupiter, but with a moderate size telescope it can be difficult, simply because of the overwhelming amount of detail visible," said Boyar. On December 31, 1989, Boyar described Jupiter's equatorial region as "sulfur orange in color." On February 17, 1990, Boyar noted that "the Great Red Spot appeared rose-orange in hue, and the color of the diffuse band south of the North Equatorial Belt appeared sulfur orange."

On March 28 Boyar reported that the South Equatorial Belt features were visible but very faint, and that the North Equatorial Belt and North Temperate Belt were noticeably darkened from previous days. "Many observers have reported a tremendous increase in activity in the North Temperate Belt," said Boyar, "and observations show the remnants of the South Equatorial Belt diminishing. Jupiter observers will be watching with anticipation as the giant planet comes out from behind the Sun late this summer." — *David J. Eicher* ☐

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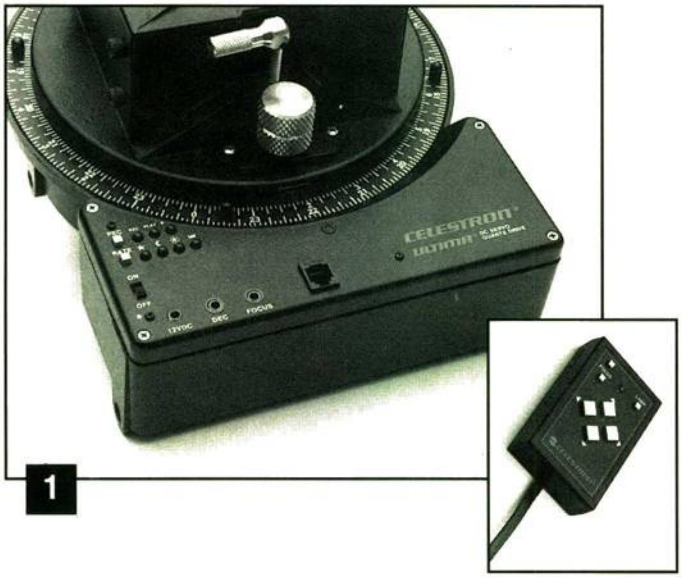
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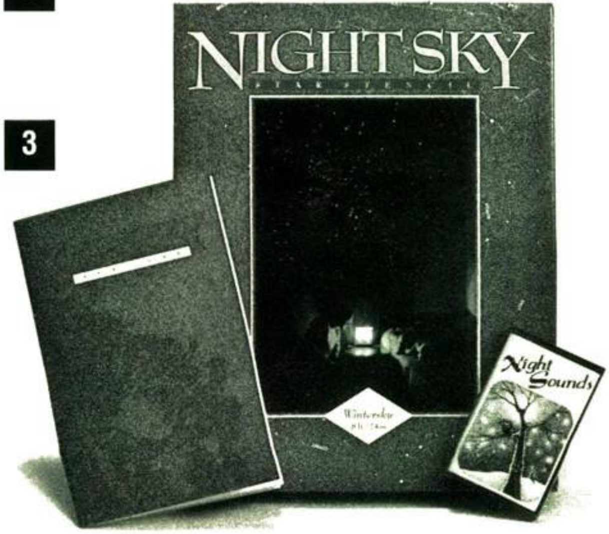
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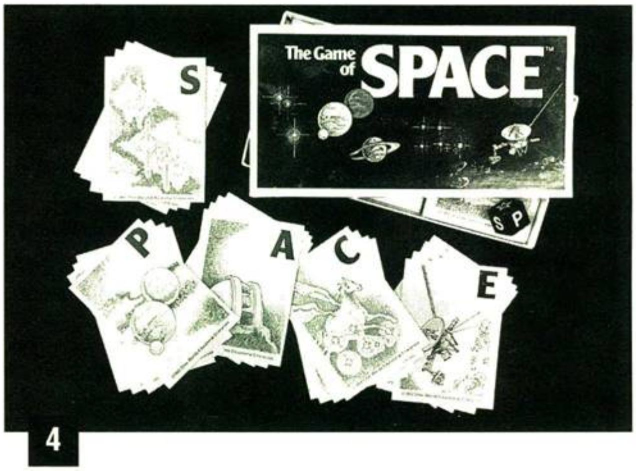
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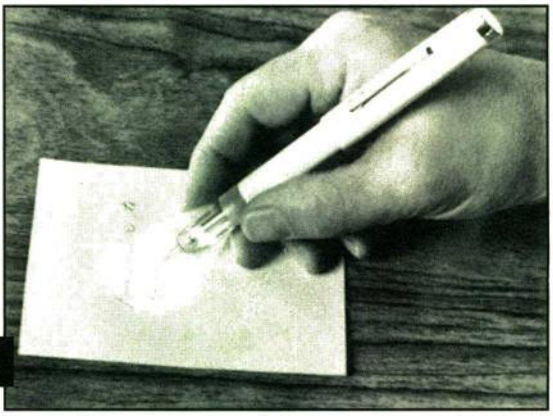

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6

1 Celestron Ultima PEC Telescopes

A Periodic Error Correction (PEC) circuit is now included on all Celestron Ultima 8 and 11 telescopes. The PEC drive uses the same Byers worm and wheel gears as previous Ultima models, but features a DC servo motor with four switchable drive rates and a 400 percent slewing speed. A microcomputer memory can record manual guiding corrections and replay the pattern of speed adjustments to compensate automatically for mechanical drive errors. The PEC drive motor and electronics require one 9-volt alkaline battery. Standard Ultima telescopes can be upgraded to the PEC drives; contact your local dealer for information.

Celestron International, 2835 Columbia Street, P.O. Box 3578, Torrance, CA 90503; (800) 421-1526 or (213) 328-9560 (8 a.m. to 4 p.m. Pacific Time). Ultima 8 telescope with PEC: $3,498.00. Ultima 11: $5,590.00.

2 Celestron 70mm Fluorite Spotting Scope

The *SS70F* features an f/8 fluorite lens for excellent color correction. The non-fluorite lens elements are multi-coated. Standard equipment includes a 26mm 1-1/4" Plössl eyepiece (yielding 22x), a 45° erect image diagonal, a 1/4x20 photo tripod adapter, and lens caps. (Tripod depicted in photo not included.)

Celestron International, 2835 Columbia Street, P.O. Box 3578, Torrance, CA 90503; (800) 421-1526 or (213) 328-9560 (8 a.m. to 4 p.m. Pacific Time). $1,698.00. Send $1.00 for spotting scope brochure.

3 Night Sky Star Stencil, Star Lore, and Night Sounds

The *Night Sky Star Stencil* kit consists of a set of stencils, glow-in-the-dark paint, and instructions to allow you to turn any ceiling or wall into a map of the night sky. Kits are available for 8-foot and 12-foot maps. *Night Sky Star Lore* is a book designed to help adults introduce children to the stars. It presents the mythology of the constellations as well as scientific information about the wonders of the night sky. A companion audio cassette, *Night Sounds,* contains sounds of creatures such as crickets, owls, and coyotes to enhance storytelling.

Ursa Major Corporation, P.O. Box 3368, Ashland, OR 97520; (800) 999-3433. 8' stencil kit: $24.95; 12' kit: $29.95; Star Lore *book: $5.95;* Night Sounds *tape: $7.95.*

4 The Game of SPACE

Test your astronomical knowledge with this new trivia game suitable for ages ten through adult. The object of *The Game of SPACE* is to correctly answer one question in each of five categories. Questions are written at four levels of difficulty. Includes 140 cards, each with four questions. Available at museums and planetariums, or directly from the manufacturer. Dealer inquiries invited.

Other Worlds Educational Enterprises, P.O. Box 6193, Woodland Park, CO 80866; (719) 687-3840. $9.95 plus $2.00 postage and handling.

5 Nitewriter Pen

For observers who like to make notes at the telescope, this new pen features a built-in, battery-operated light. It comes with a bulb and an extra ink cartridge.

T. F. Holland, 142 Pond Street, Wakefield, RI 02879; (401) 783-7133. $8.95 plus $2.00 shipping and handling.

6 Optical Cleaning Kits

Thaural Research announces two cleaning kits for telescope optics. The CL1 kit is for mirrors and uses three spray-on chemical solutions. The CL3 kit is for lenses and eyepieces and uses two solutions and absorbent cotton pads.

Thaural Research Inc., P.O. Box 65, Mooers, NY 12958; in Canada: 5585 Verdi, Brossard, Quebec, Canada, J4W 1B4; (514) 672-5697. CL1: $11.25; CL3: $8.00; add $3.00 shipping and handling for small orders. ☐

This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.

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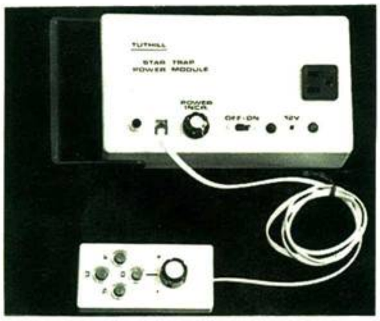

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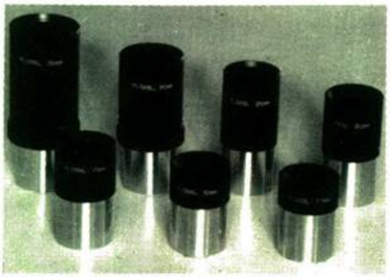

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Product Reviews

FIRST LOOK AT A FABULOUS CCD

Star I CCD Camera, (Photometrics Ltd., 2010 N. Forbes Blvd., #103, Tucson, AZ 85745-1418; (602) 623-8961), list price: $14,850.

The CCD revolution is about to burst upon amateur astronomy. The forerunners of that revolution are the generation of CCD cameras developed for professional astronomy. ASTRONOMY was privileged to borrow such a camera from Photometrics for two weeks in June.

I set out to examine the Star I CCD camera from an astronomy hobbyist's point of view, rather than as a data-gathering instrument for science. I operated the camera in stand-alone mode, without benefit of image-processing from an attached Macintosh II or PC AT. I was curious to discover what an astrophotographer and deep-sky observer could do with a powerful and ultra-sensitive detector on a modest telescope.

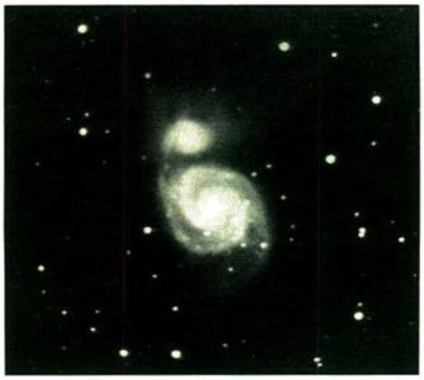
What I found was astounding. Mounted on a 6-inch f/5 telescope in my small backyard observatory, the camera proved capable of recording the Hercules Cluster of galaxies — a deep-sky object that is difficult to see even in my 20-inch telescope under better skies than I have at home. I found that 30-second exposures are perfectly adequate to reveal the North America and Pelican Nebulae, the nebulosities around Gamma Cygni, and the Cygnus Loop.

The Star I arrived in three large boxes containing the CCD camera head (about 4 inches diameter and four inches deep), the camera controller box, a high-quality video monitor, a liquid circulation cooling unit, a mare's-nest of cables and tubes, a mouse, and a small stack of manuals and instruction booklets. Several ASTRONOMY staffers gathered around, and we cleared off my desk and sorted out the system components. Assembling this daunting array of gear took only about fifteen minutes — and the camera worked perfectly. Our first picture showed my face a bit out of focus on the video monitor. Our second picture showed Al Dyer in focus, with every hair in his beard perfectly sharp.

Mounting the Star I camera head on my 6-inch telescope was duck soup. The camera head has a Nikon bayonet fitting. I coupled a 2-inch-to-Nikon adaptor to the camera and plugged the camera into the telescope's focuser. Arranging the monitor, control unit, cabling, and coolant lines in an observatory only eight feet square proved slightly problematic, but once I realized the cooling unit and electronics could be supported close to the telescope on a low box, everything worked beautifully. With the mouse ensconced on top of the video monitor, operation was convenient and easy.

The first evening I spent familiarizing myself with the camera and its operation, and learning what makes a good CCD image. With my f/5 telescope, ten-second exposures are perfect for locating almost any celestial object and sixty-second exposures bring up clean, sharp detail. Six hundred seconds pulls out faint detail that is awesome.

The second night I concentrated on shooting familiar Messier objects and making short exposures of Milky Way fields that I know well from years of astrophotography. A ten-minute exposure of M51 revealed beautiful faint streams of stars thrown out in this intragalactic collision.



After waiting out several nights of rain and thunderstorms, I devoted the last night to faint objects that are normally beyond the pale. The Coma and Hercules clusters of galaxies showed hundreds of members clearly and unmistakably in a one-minute exposure.

The Star I CCD camera almost has to be seen to be believed. The images I recorded are beyond anything I ever dreamed of getting through a 6-inch telescope. The operation of the camera was flawless, and in three nights I gained experience enough to run it reliably. In so short a time I cannot pretend to have exploited the camera's full potential, but what I achieved in that time has left me wanting more.

—*Richard Berry*

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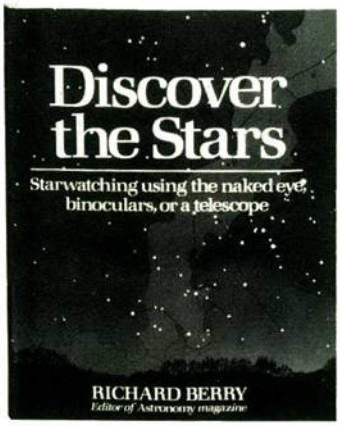
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Astronomy Books

GETTING PERSONAL WITH THE SKY

Nightwatch: An Equinox Guide to Viewing the Universe by Terence Dickinson, (Firefly Books, 1989), ISBN 0-920656-89-7, 160 pages, spiral-bound softcover, $24.95.

Beginning in amateur astronomy today is no easy task. Many beginners have started down the road to the universe only to be driven back to the glow of the electronic fireplace by frustration and boredom.

The new edition of *Nightwatch* whets the appetite of the neophyte observer with a mix of information and an enthusiasm that leaves the reader eager for more. Early in the book (page 8 to be exact), Dickinson states the book is for "those with a budding interest in the cosmos" and that the book "will enable the uninitiated to make intelligent decisions about pursuing backyard astronomy." In my opinion, Dickinson succeeds marvelously.

The design of the book places beautiful and informative art and photos on almost every page. It is well paced and personal. The style stands in refreshing contrast to most amateur handbooks, which immediately strike a chilly or impersonal tone — almost as if *enjoying* the sky is somehow inappropriate. Dickinson's enthusiasm may be just as important — maybe even more so — as information to a beginner.

One of the book's nicest features is the simple and effective sky charts. The explanations that accompany them are interspersed with gems of information that liven up the guided tour of the seasonal skies. Even an experienced observer will come away with new perspectives. The deep-sky charts in chapter 6 are also clearly drawn and easy to understand. They give readers plenty of help in finding their way around the sky and contain the kind of information that novice telescope users need.

I enjoyed this book and heartily recommend it. If you are looking for a book for someone who wants to get started in astronomy, this book is a great place to start. If you are an experienced observer, the book will bring back that sense of wonder you felt the first time you peeked through an eyepiece. — *Michael Porcellino*

The Moon

The Moon Book by Kim Long, (Johnson Books, 1988), ISBN 1-55566-028-2, 128 pages, paperback, $6.95.

This simple, basic guide to lunar "facts and feats" describes the Moon's motions, lunar expeditions, and such phenomena as tides, the names of the Full Moons, and so on.

The Face of the Moon, (Linda Hall Library, 5109 Cherry St., Kansas City, MO 64110; 1989), 47 pages, paperback, $8.00 (plus $2.00 postage).

Subtitled "from Galileo to Apollo," this book documents an exhibit of forty-five books, charts, drawings, and photographs that spans more than 350 years of lunar study. The black-and-white illustrations typically measure about 3 by 4 inches and demonstrate a wide range of techniques in depicting lunar topography.

General Astronomy

Modern Technology and Its Influence on Astronomy, edited by J. V. Wall and A. Boksenberg, (Cambridge University Press, 1990), ISBN 0-521-34313-5, 323 pages, hardcover, $59.50.

This is a collection of technical papers presented at a meeting on astronomical instrumentation held at the Royal Greenwich Observatory in August 1986. Contributors describe the impact of modern instrumentation on astronomy. Topics include radio interferometry and VLBI, radio image processing, optical interferometry, large mirrors, electronic detectors, and the *Hubble Space Telescope*.

Galileo: Pioneer Scientist by Stillman Drake, (University of Toronto Press, 1990), ISBN 0-8020-2725-3, 261 pages, acid-free paper, hardcover, $37.50.

The bulk of this work by the world's foremost Galileo scholar is a detailed examination of Galileo's working papers on physics, in particular the way in which he devised a rule for the acceleration of gravity. About a third of the chapters, however, focus on astronomical topics, such as the telescope, comets, and Copernicanism.

Cosmology

Physical Cosmology and Philosophy, edited by John Leslie, (Macmillan, 1990), ISBN 0-02-370021-1, 277 pages, paperback, $9.95.

Leslie's collection of essays and articles by both cosmologists and philosophers delves into the most compelling scientific and philosophical issues in modern cosmology. You'll find no Babylonian creation myths here: the book is entirely devoted to 20th century cosmology and its philosophical implications. Cosmologist Jayant Narlikar, in an essay entitled "Was There a Big Bang?" examines the reasoning that has led astronomers to make this theory the very foundation of modern cosmology. Other essays include "Argument from the Fine-Tuning of the Universe" by Richard Swinburne, "A Cozy Cosmology" by Heinz Pagels, "Beyond the End of Time" by John Archibald Wheeler, "What Caused the Big Bang?" by Paul Davies, and "The Universe: Inflation out of Chaos" by Andrei Linde. An introduction summarizes the essays and puts them in chronological context. Even the glossary is a pleasure to read. For example, the definition of universe begins playfully: "Everything in existence, ever, anywhere."

Stars and Galaxies

FGK Stars and T Tauri Stars by Lawrence E. Cram and Leonard V. Kuhi, (NASA, 1990), GPO stock number 033-000-01073-7, 360 pages, paperback, $18.00. (Order from: Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-0001.)

One of a technical monograph series on nonthermal phenomena in stellar atmospheres, this book provides a summary of the best space- and ground-based observations of these "cool" stars of the main sequence, as well as current theories on nonthermal phenomena in their atmospheres.

BRIEF NOTES

Stars

Calibration of Stellar Ages, edited by A. G. Davis Philip, (L. Davis Press, 1989), ISBN 0-933485-09-3, 248 pages, hardcover, no price given.

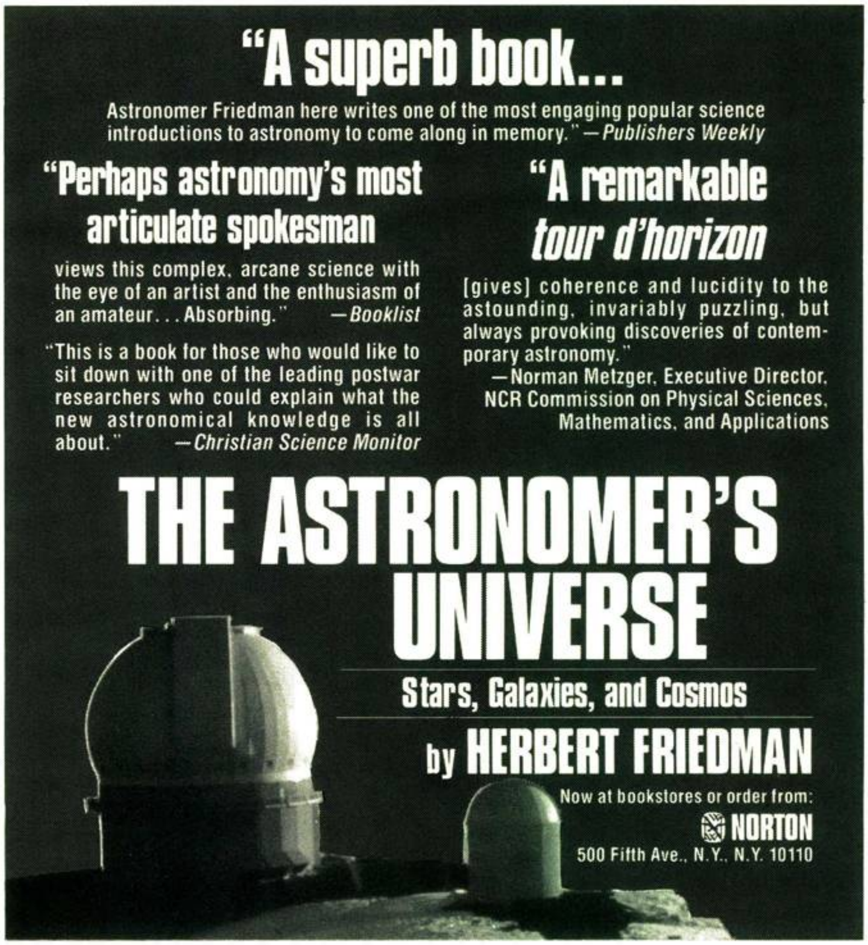
Classical Novae, edited by M. F. Bode and A. Evans, (John Wiley and Sons, 1989), ISBN 0-471-92058-4, 341 pages, hardcover, $163.00.

Dynamics of Dense Stellar Systems, edited by David Merritt, (Cambridge University Press, 1989), ISBN 0-521-36432-9, 251 pages, hardcover, $49.50.

Telescopes and Instruments

Fiber Optics in Astronomy, edited by Samuel C. Barden, (Astronomical Society of the Pacific, 1988), ISBN 0-937707-20-1, 295 pages, hardcover, no price given.

Synthesis Imaging in Radio Astronomy, edited by Richard A. Perley, Frederic R. Schwab, and Alan H. Bridle, (Astronomical Society of the Pacific, 1989), ISBN 0-937707-23-6, 509 pages, hardcover, $32.00. ☐



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—Norman Metzger, Executive Director, NCR Commission on Physical Sciences, Mathematics, and Applications

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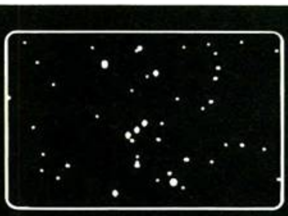

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Meetings & Events

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StarConn '90, Wesleyan University, Middletown, Connecticut. Sponsored by the Astronomical Society of Greater Hartford. Contact: Suzanne Marinan, 367 Suger Hill Road, Tolland, CT 06084-2116.

September 14-15
Alberta Star Party 1990, near Kinbrook Island Provincial Park, Alberta. Contact: Alberta Star Party 1990, c/o R. Lewis, 712-34th Street N.W., Calgary, Alberta, Canada T2N 2X9. Phone: (403) 262-3305 (days), (403) 283-0570 (evenings).

September 14-15
4th Annual Observing Party, Cathedral Gorge State Park, Panaca, Nevada. Contact: Jim Mellor, Great Western Hotels, 401 South Casino Center Boulevard, Las Vegas, NV 89101. Phone: (800) 634-6635.

September 14-16
Astrofest '90, Camp Shaw-Waw-Nas-See, Kankakee, Illinois. Sponsored by the Chicago Astronomical Society. Contact: Astrofest, P.O. Box 596-A, Tinley Park, IL 60477.

September 14-16
4th Annual Whirlpool Star Party, Birr, County Offaly, Ireland. Sponsored by the Limerick Astronomy Club. Contact: Tony O'Hanlon, 26 Ballycannon Heights, Meelick, County Clare, Republic of Ireland.

September 14-16
Star Party, Billy Dunlop Park, Clarksville, Tennessee. Contact: Bob Embler, P.O. Box 835, Department A, St. Bethlehem, TN 37155.

September 18-23
Okie-Tex Star Party, Lake Murray State Lodge, near Ardmore, Oklahoma. Sponsored by the Oklahoma City Astronomy Club. Contact: Okie-Tex Star Party, c/o Beryl Cadle, 6616 NW 20th, Bethany, OK 73008.

September 20-21
Iowa Convention of Amateur and Professional Astronomers. Contact: C. L. Allen, c/o Des Moines Astronomical Society, 2307 49th Street, Des Moines, IA 50310-2538.

September 20-22
3rd Annual Ozarks Star Party, near Joplin, Missouri. Contact: Don Walton, 2626 Ilinois, Joplin, MO 64804. Phone: (417) 623-3972.

September 21
3rd Annual Star Party, Roseburg, Oregon. Sponsored by the Umpqua Amateur Astronomers. Contact: Umpqua Amateur Astronomers, 3150 West Military, Roseburg, OR 97470.

September 21-22
All Arizona Star Party, Empire Ranch, Arizona. Sponsored by the Tucson Amateur Astronomy Association. Contact: Tucson Amateur Astronomy Association, 70 West Forrest Feezor, Tucson, AZ 85747.

September 21-23
Eastern Iowa Star Party '90, Sherman Park, near Dixon, Iowa. Sponsored by the Quad-Cities Astronomical Society. Contact: Dana Taylor, P.O. Box 3706, Davenport, IA 52808. Phone: (319) 322-2557.

September 22, October 20
6th Annual Blue Ridge Parkway Regional Stargaze, Julian Price Park, near Blowing Rock, North Carolina. Contact: Greg Kirby, 12 East Street, Granite Falls, NC 28630. Phone: (704) 396-7656.

September 28-29
36th Annual AstroAssembly, Seagrave Memorial Observatory, North Scituate, Rhode Island. Sponsored by Skyscrapers, Inc. Contact: Brian Magaw, P.O. Box 325, Pascoag, RI 02859. Phone: (401) 568-8424.

September 29
Astronomy Day, Pensacola, Florida. Sponsored by the Escambia Amateur Astronomers Association. Contact: Margret Hildreth, Escambia Amateur Astronomers Association, 4100 Lillian Highway, Pensacola, FL 32506. Phone: (904) 456-0078.

October 10-13
26th Annual Conference of the Great Lakes Planetarium Association, Children's Museum of Indianapolis, Indiana. Contact: Sharon K. Parker, SpaceQuest Planetarium, The Children's Museum of Indianapolis, 3000 North Meridian Street, Indianapolis, IN 46208. Phone: (317) 924-5431. ☐

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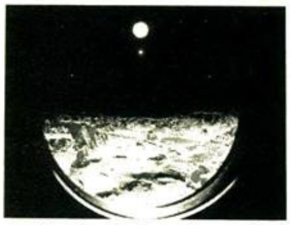
When you write to organizations listed in Meetings and Events, include a self-addressed, legal-size envelope with your request for information.



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Readings and Resources

Origins of Comets (page 28)

The Origin of Comets by M. E. Baily, S. V. M. Clube, and W. M. Napier, (Pergamon Press, 1990). An up-to-date survey of theories past and present of comet origins. Technical in places, but readable and very comprehensive.

Voyager (page 38)

"Into the Night Between the Stars," by D. Venkatesan and S. M. Krimigis, ASTRONOMY, February 1990. Details the plans for the "interstellar mission" for *Voyagers 1* and *2* as they coast out of the solar system.

Hubble's New Universe (page 44)

The Space Telescope, by George Field and Donald Goldsmith, (Contemporary Books, 1989). Two noted astronomers explain the workings of *HST* and its intended observation programs.

"From Idea to Observation," by Ray Villard, ASTRONOMY, June 1989. An excellent overview of how astronomers will conduct their remotely-controlled observations with *HST*.

Mars (page 74)

Introduction to Observing and Photographing the Solar System by Thomas A. Dobbins, Donald C. Parker, and Charles F. Capen (Willmann-Bell, 1988). An excellent and detailed overview for amateurs on how to observe Mars and other solar system bodies.

CREDITS

Cover: Tony Hallas and Daphne Mount, 14-inch SCT at f/7.5, hypered Fuji Super HG 400 film, 25-min. exposure; *page 4:* Ronald Royer, 105mm f/2.5 lens, Fuji 1600 film, 2.5-min. exposure on April 19, 1990; *page 22:* Alfred McEwen, U.S.Geological Survey, Flagstaff; *page 23 left:* D. J. Eicher; *page 23 right:* R. L. Berry; *pages 28-29:* painting by Mark Paternostro; *pages 30-31:* painting by Paul Hudson; Beta Pictoris image by Bradford Smith and Richard Terrile, courtesy the University of Arizona and the Jet Propulsion Laboratory; *pages 32-33:* painting by Paul Di-Mare; *page 34: Giotto* photo of Comet Halley nucleus courtesy of the Max-Planck-Institut für Aeronomie; *page 36:* illustration by Tom Hunt; photo of Comet Austin by Michael Stecker (8-inch f/6 telescope); *pages 38-43:* NASA; *pages 44-45:* HST deployment, NASA; *page 46:* nucleus of Comet Halley, courtesy European Space Agency; *page 47:* Crab Nebula photo by Bill Iburg; *page 48:* circumstellar disk in the Beta Pictoris system, courtesy Ben Zuckerman and Harland Epps, UCLA, John Gradie and Joan Hayashi, University of Hawaii, and Robert Howell, University of Wyoming; *page 49:* spiral galaxy M51, courtesy Kitt Peak National Observatory; *page 50:* artist's conception of the black hole "engine" at the center of M87, courtesy Dana Berry, Space Telescope Science Institute; *page 59:* James Smallwood, 300mm f/4.5 lens, Ektar 25 film, 30-sec. exposure on April 8, 1989; *pages 62-65:* all photos by Tony Hallas and Daphne Mount on hypered Fuji Super 400 film; *pages 62-63:* 14-inch SCT at f/7.5, 45-min. exposure; *page 63 top left:* 14-inch SCT at f/7.5, 20-min. exposure; *page 63 top right:* 14-inch SCT at f/7.5, 5-min. exposure; *page 64 top:* 6-inch f/7.5 EDF refractor, 30-min. exposure; *page 64 bottom:* 14-inch SCT at f/7.5, 50-min. exposure; *page 65 top:* 14-inch SCT at f/7.5, 50-min. exposure; *page 65 bottom:* 14-inch SCT at f/7.5, 45-min. exposure; *page 67:* Stanislav Djorgovski and Hyron Spinrad, 4-meter telescope at Kitt Peak, October 10, 1980, courtesy H. Spinrad; *page 75:* Donald Parker, 41-cm f/6 Newtonian at f/165, 3-sec. exposure on Tech Pan film, September 21, 1988; *page 77:* Mars map courtesy Jeff Beish; *page 71 top:* Martin E. Hale, 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, 5-min. exposure on March 18, 1990; *page 71 bottom:* Martin E. Hale, 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, 5-min. exposure on April 25, 1990; *page 72 top left:* Michael Stecker, 8-inch f/4 reflector, hypered Fujichrome 100 film, 20-min. exposure, April 28, 1990; *page 72 top right:* Chuck Vaughn, 350mm f/2.8 lens, hypered Tech Pan film, 10-min. exposure with a violet filter on April 29, 1990; *page 72 middle:* Bob Yen, 8-inch f/1.5 Schmidt camera, hypered Tech Pan film, 4-min. exposure on April 29, 1990; *page 72 bottom:* Dennis Sørensen, 135mm f/4 lens, hypered Tech Pan film, 8-min. exposure on April 28, 1990; *page 73 top:* George E. Fowler, 14-inch f/11 SCT, Star I CCD, 60-sec. exposure, May 12, 1990, printed with a Macintosh computer and Tektronix thermal color printer; *page 73 bottom left:* John Stevenson, 10-inch f/7 reflector, 103a-O film plus O filter, 10-min. exposure, May 6, 1990; *page 73 bottom right:* Michael Stecker, 8-inch f/4 reflector, hypered Tech Pan film, 20-min. exposure on May 20, 1990; *page 78:* Alfred Lilge, 12.5-inch f/8 Proscope, 098 film, 120-min. exposure; *page 79:* Chris Floyd; *page 80 top left:* Ben Mayer, 14-inch f/11 SCT, Ektachrome 200 film, 20-min. exposure with a cold camera; *page 80 top right:* Lee C. Coombs, 10-inch f/5 reflector, Ektachrome 400 pushed to ISO 800, 10-min. exposure; *page 80 bottom left:* Mike Mayerchak; *page 85 top:* Chris Schur, 14-inch f/5 reflector, Ektar 1000 film, 10-min. exposure on May 6, 1990; *page 85 bottom:* Ken Burgess and Chris Schur, 180mm f/2.8 lens, hypered Tech Pan film, 15-min. expsure on April 27, 1990; *pages 86-87:* Marco Antonio De Bellis, 8-inch f/10 SCT, hypered Tech Pan film, 90-min. exposure on April 28, 1990; *page 86 middle:* Jeffrey Jones, 8-inch f/10 SCT, hypered Tech Pan film, 110-min. exposure on April 27, 1990; *page 86 bottom left:* Paula Drake, 12.5-inch f/5 reflector, Konica 3200 film, and a 30-min. exposure; *page 86 bottom right:* Jean Dragesco, 14-inch f/11 SCT, Daystar H-alpha filter, Tech Pan film; *page 87 bottom:* Tony Hallas and Daphne Mount, 6-inch f/8 EDF refractor, hypered Tech Pan film; *page 88:* Tony Hallas and Daphne Mount; *page 89 left:* Gregory Terrance, 16-inch reflector at f/125, Tech Pan film, 1-sec. exposure on January 31, 1990; *page 89 right:* Gregory Terrance, 16-inch reflector at f/60, Tech Pan film, 1-sec. exposure on February 7, 1990.

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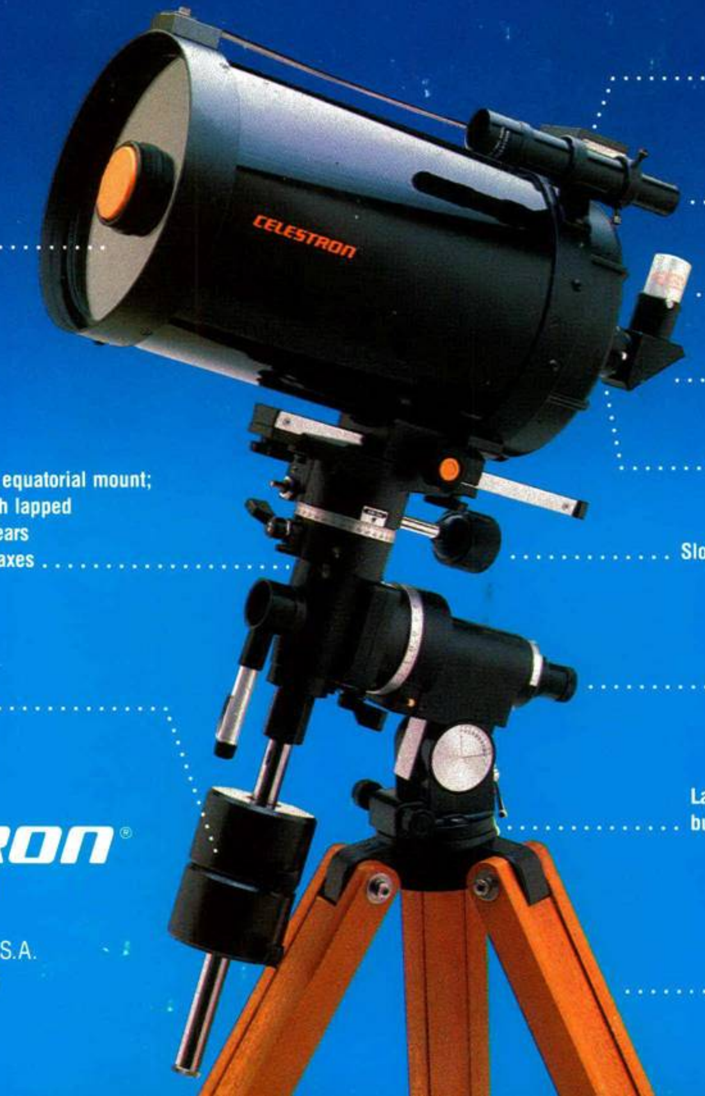
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